A text-book of Agriculture

J. Mollison

PREFACE.

The fields and garden crops of the Bombay Presidency are very numerous. Only the more important of them have been dealt with in this work. The information given has been collected by the writer by personal observation in the field, from the records of the Bombay Agricultural Department, from notes kindly put at his disposal by Professor Middleton, late of the Baroda College; Mr. P. R. Mehta, M.R.A.C., of the Gujerat Revenue Survey; and by Professor Gammie, College of Science, Poona. Dr. Watt's "Dictionary of Economic Products" and Messrs. Duthie and Fuller's "Field and Garden Crops" have been freely exploited for information.

The usefulness of the work for agricultural students, district officers and others would be enhanced considerably by correct illustrations and botanical descriptions of the various plants referred to. This work the Director of the Bombay Botanical Survey has now in hand. Professor Gammie promises that such illustrations and descriptions will be available, should an extended edition of the "Bombay Field and Garden Crops" be, in the future, printed. The student has already at hand excellent illustrations in Messrs. Duthie and Fuller's "Field and Garden Crops."

The writer's present effort has been to give fairly full description of the conditions of soil and climate under which each crop is grown, with details of cultivation, outturn, &c. It is hoped that the work will, in particular, be useful to agricultural teachers, agricultural students, and district officers. It will help the latter to become easily acquainted than at present with Indian agricultural methods and facts.

The crops which have been described are grouped as under :—

(1) Cereals.
(2) Pulses.
(3) Oilseeds.
(4) Irrigated garden crop.
(5) Fibre plants.
(6) Fodder crops.
(7) Drugs, narcotics and dyes.

I am indebted to the office establishment of the Survey Commissioner and Director of Land Records and Agriculture for examination and correction of proofs and, in particular, to Mr. Yashvant Nilkanth, the Superintendent in that office.

J. M.

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BOMBAY CEREALS.

THERE are fourteen cereals in common cultivation in the Bombay Presidency. Professor Gammie, of the College of Science, Poona, describes the general characters as follows :—

The *roots* are fibrous, and the taller species are additionally supported by *adventitious roots* thrown out from the lower joints. The *stems* or *culms* are hollow or solid, and are divided into distinct *joints*. The *leaves* are alternate, usually long and tapering, longitudinally parallel-veined, and the margins are often armed with forward-pointing, minute, cutting hairs. The lower part of the leaf, which is wrapped round the stem, is the *sheath*. At the apex of the sheath, where the blade of the leaf is given off, is a small appendage, often hairy, called the *ligule*. The part bearing the flowers or *inflorescence* is terminal, forming *panicles*, *racemes* and *spikes*, and the ultimate divisions are called *spikelets*. Each spikelet consists of 3 or 4 or more scaly bracts, called *glumes*, of which the two lowest are empty ; the third and fourth and succeeding glumes, if present, are called the *flowering glumes*, and each of these, as a rule, contains a similar, but transparent, bract, called a *pale*. The actual flower of the plant is within the pale. The external organs—*perianth* of ordinary flowering plants—are represented by 2 (rarely 3 or 6) minute, fleshy scales, called *lodicules*. The *stamens* are normally 3 (rarely 1, 2 or 6) ; their stalks or *filaments*, are threadlike and pendulous, and support the two-celled *anthers* by a point on their backs (*versatile*). The *pollen* is distributed in the form of a dry powder by the agency of the wind. The *pistil* is seated in the centre of the flower ; its lower inflated part, which becomes the grain, is the *ovary*, containing a single *ovule* or germ which is fertilized through the two feathery, spreading *styles* which form the upper part of the pistil. The *grain* is the *fruit*, and it is generally free from the flowering glume and pale, but sometimes is adherent to them. The *embryo* or future plant is small, and is situated at the base and outside the body of the grain.

Sorghum vulgare—Pers. or *Andropogon Sorghum*—Brot.

GREAT MILLET. { *Jowár* or *Jowári* ... ... { Gujaráti. Maráth. / *Jola* ... ... Kánarese.

Natural order—*Gramineæ*.

Tribe—*Andropogoneæ*.

Habitat. It is doubtful whether *jowár* was originally a native of India. A form of sorghum was cultivated in India long before the introduction of the present cultivated form of *jowár*. Numerous varieties of the cultivated form are now grown all over India. The guinea corn of the West Indies, the dhurra of Egypt, the kaffir corn of South Africa, the broom corn of Italy, the United States and Australia are all sorghums, somewhat similar to the common *jowár* of India; but whether the species are the same cannot be stated with certainty.

Botanical Description (Professor Gammie).

Andropogon Sorghum—Brot.

Annual, tall; *stems* thick, solid; *leaves* large and broad, smooth, except near the base, midrib broad, margins rough and cutting. *Panicle* dense, ovate, erect when young, nodding before the ripening of the grain, branches and branchlets in crowded whorls. *Spikelets* in pairs, each one-flowered, the lower stalkless, hermaphrodite and producing a grain, the upper stalked, male only; *glumes* equal; *grain* white or red.

Distribution in the Bombay Presidency. The crop occupies 7,000,000 to 8,000,000 acres annually. Its distribution is regulated by the character of the soil, as well as by the average rainfall. Where the rainfall is excessive, it gives place to rice. On the *gorádu* (sandy loam) soils of Gujarát and the thin soils of the Deccan, it gives place to *bájri*. Elsewhere in the Presidency, except, perhaps, in the Panch Mahál, where maize is the staple, and in certain localities favourable for wheat, it is the most important food-grain crop. In the Konkan, on account of the heavy rainfall, it occupies a very small area. In the Deccan, Sholápur grows nearly 1,500,000 acres, Násik about 1,000,000, and other collectorates from 500,000 to 800,000 acres each. In the Karnátak, Bijápur grows 1,800,000 acres, Belgaum 750,000 acres, and Dhárwár about 600,000 acres. In Gujarát, Ahmedabad returns 350,000, Kaira 70,000, Panch Mahál about 5,000, Broach 100,000, and Surat 118,000 acres. These figures are, to some extent, misleading, because it is the general practice to grow *jowári* and nearly all cereals with a subordinate pulse mixture. The proportion of mixture can only be estimated, and the exact areas under different crops only approximated.

Jowár is the staple grain crop where black or mixed black soils predominate, provided the rainfall is moderate and well distributed. The rainfall for *kharif jowár* should not exceed 40 to 45 inches, and in the best districts is ordinarily from 30 to 35 inches. *Rabi jowár* is extensively grown in the Presidency, and the success of this crop depends upon two conditions—(*a*) upon a soil that is dense enough and deep enough to retain moisture, (*b*) upon sufficient late rainfall. The September and October rainfalls are specially important to *rabi jowár*, and if there is a moderate rainfall in November or December also, the success of this crop is assured. The best *kharif jowár* is, perhaps, grown on black soil and in rotation with cotton, but the crop does particularly well also on the deep, alluvial soils of Gujarát, especially on *besar* soils which are clay loams. The best rabi crops of *jowár* are probably grown in Broach on very deep, black soil which is so dense and deep that it gets sodden during the monsoon rainfall, and therefore is unsuitable for *kharif jowár*. It is, however, so retentive of moisture that such rain as falls after October is usually of immaterial importance to the *rabi* crop. Season. Soils.

Various pulses, oil seeds and fibre crops are generally grown with *kharif jowár*. In Gujarát there is a greater variety than elsewhere. There, subordinate to *jowár*, we find *tuver*, *guvár*, *math*, *mag*, *chola*, *adad* (all pulses), castors and *tal* (oil seeds), and *ambádi* and *rozi* cotton (fibre plants). The group of subordinate crops referred to are not often sown all together, but mixed according to the fancy or inclination of the cultivator. In Khándesh, *udid* and *ambádi* are ordinarily sown with *jowár*. In the black soil of Surat, *tuver* is always subordinate to *jowár*, and generally also *mag*. In the Deccan, on mixed black soil, *tur*, *ambádi*, *udid*, and sesamum and on distinctly light soil, *math*, *kulthi* and sometimes niger seed are generally subordinate to *jowár*. Mixtures.

Rabi jowár in Broach is generally sown alone. If sown earlier than usual on account of favourable September rain, there may be a sprinkling of *tuver* and sesamum and also *chibdi*. The latter is a small cucumber which, with sufficient moisture in the soil, spreads its trailing stems during December and January through the stalks of *jowár*, and yields bountifully. *Rabi jowár* in the Deccan and in parts of the Southern Marátha Country has usually subordinate to it rows of safflower (*kardai*). This oilseed generally also occupies the headlands, because its leaves are prickly, and stray cattle are not inclined to pass through it to the principal crop. A sprinkling of linseed is occasionally sown with *rabi jowár* or this oilseed may occupy separate rows.

Cultivation of Kharif Jowár in the Deccan.

The land should be ready for sowing by the end of June at latest. Preparatory tillage generally begins in the hot weather. The heavy bladed harrow (*vakhar*) is then worked. This implement is generally weighted down with a stone, or the driver stands on the head piece, so that the penetrative power of the blade is increased. It scrapes or scarifies the surface, uproots the stubble of the previous crop, and forms a thin layer of loose soil which, when sufficiently moistened by monsoon rain, provides a favourable seed bed. Annual weeds spring up early in June after the soil has been well soaked with rain. They can easily be destroyed if the *vakhar* is worked two or three times before sowing. This working tends to deepen the tilth. At the same time the firm seed bed which *jowár* likes is preserved. A firm seed bed is important, because, if the crop is sown on loose soil, there is considerable risk of "lodging" by rain or wind. *Jowári*, in rotation with cotton on black soil, is rarely manured. Any manure that is available from time to time is given to the cotton. In some parts of the Deccan *jowár*, with a subordinate pulse mixture, is taken year after year on the same land. In this case manure is occasionally given, and should always be applied in a thoroughly decayed condition in the hot weather.

The subsequent tillage mixes it properly with the soil. *Jowár* responds quickly to the action of manure. The effect of a liberal application of old farm yard manure becomes clearly manifest, especially in a year of favourable rainfall.

The seed rate and the conditions which regulate it.

The seed rate for *jowári* varies. Some varieties which under favourable conditions of cultivation have large heads of grain require a smaller seed rate than other varieties having smaller heads of grain. It is always safe to sow more seed than is actually needed to provide a full plant. The risks of failure of the first sowing is thus minimized. Heavy downpours of rain may destroy many young plants. These are delicate when young, but are not easily hurt after they are 4″ to 6″ high. It is a simple matter to remove superfluous seedlings, whereas, if there are many vacancies, the field may have to be resown. Late sown *kharif jowár* in average seasons rarely produces a satisfactory crop. There are other conditions which should determine the seed rate. The straw or stalks known as *kadab* in Gujarát and *kadbi* or *karbi* in the

Deccan provides the chief fodder for cattle in the cold and hot weather. Near populous centres this fodder commands a higher price than in out districts. Where a good market for *karbi* exists, there the seed is thickly sown. A thick crop and fine thin stalks are thus produced. The *karbi* is, therefore, excellent in quality. The cultivator by thick sowing gets a larger yield of fodder, but a reduced outturn of grain. The gross outturn is, however, worth more than from a crop specially grown for grain. The ordinary seed rate for a grain crop is 6 to 8 lbs. per acre, along with 1½ to 2½ lbs. of subordinate pulse, &c., mixture. These seeds are generally mixed before sowing, and are sown with a 4-coultered drill. The distance between the rows is generally about 14". The surface should be levelled after sowing with the head piece of the *vakhar*, the prongs and blade being removed. As a rule, on well prepared land, *jowári* only requires one hand weeding. A thriving crop soon shades the ground, and weeds are more or less suppressed. Still the *jowár* seedlings are so small and delicate when they first spring up that weeds, if unchecked, soon make greater progress than the crop with disastrous result. Timely hand weeding once or oftener is, therefore, necessary. Bullock hoeing is of equal importance, not so much because weeds are thereby destroyed, but because the surface soil dries and cakes after heavy rain, and stirring is then very beneficial. The *kolpa* (the only bullock hoe used in the Deccan) should be used at least three times at intervals of a fortnight. The first hoeing should be given after hand weeding and about three weeks or a month after sowing. *Kharif jowár* comes into flower in August and September in the Deccan, and is ripe in October and November. The pulses are usually reaped previously. *Udid* ripens earlier than other pulses. *Math* on moderately light land may ripen after the *jowár*. The pods of *chavli* and *mug* are usually plucked before they are ripe, and used as green vegetable. *Ambádi* usually is left standing in the field after the *jowár* is ripe.

Watching.

Birds are very destructive to *jowár* and some other crops. They begin their depredations when the ears begin to fill. Fields have to be watched from daylight to sunset for a month or six weeks before harvest. A large field can only be effectively watched by several watchers; hired labourers are of very little good for this work. The owner of a field and members of his family standing on raised platforms placed in the crop do their utmost to scare birds away by slinging stones or hard lumps of earth and producing a hideous din by beating old kerosine oil tins and in other ways which are likewise productive of much noise.

Harvesting.

The method of harvesting depends greatly upon the character of the crop. If the stalks are coarse and tall, they are cut with a sickle.

A stubble of considerable length is left. If the crop is thick and the stalks fine, the plants are partially reaped, partially uprooted with a blunt sickle, and shaken, as far as possible, free of adhering earth. They are laid evenly in swathe. Coarse stalks from a thin crop are laid neatly in bundles. The heads of grain, after exposure to the sun for three or four days, are cut off by women, and carted to the threshing floor. Men then bind the stalks (*karbi*) into sheaves (*pendhis*), and these, when dry, should be carefully stacked.

A curious method of storing *karbi* in the Southern Maratha Country.

A curious method of storing the *karbi* prevails in the Southern Maratha Country. The bundles are built into neat oblong heaps in the field. Each heap is built with a slope from the ground to the ridge, and, when complete, is protected along the sides, ends and top with big lumps of black soil, which are built or packed closely together. These heaps, when complete, look like large boundary marks. Cattle can freely graze over the stubble, but can get no access to the stored fodder.

Threshing.

The threshing of *jowár* is usually done in the ordinary way under the feet of bullocks. A stout pole is placed upright in the ground in the middle of the threshing floor. A good threshing floor can be made on black soil. The floor is prepared by puddling with water and by driving a pair of bullocks yoked to a cart round and round until the puddled surface gets smooth and indurated. The surface is finally smeared with a plaster made of earth, cowdung and water. One bullock is so tied to the central post that he can walk freely round it and not entangle the tying rope. Other bullocks are ranged alongside the first bullock and tied each neck to neck. They can in this manner be driven round more or less in line. The heads of grain are usually alone threshed, not the stalks. The heads of grain are put on the threshing floor about 6″ deep. In the case of a crop with short, thin stalks, straw and grain may be trampled together; the depth should then be about a foot. As the treading proceeds, the mass should be raked up or turned over to facilitate the work. The treading out of corn is in the Deccan distressingly hard work for the cattle, because they are tied together in such a cramped or confined manner. Gujarát cultivators manage the work much better. Two or three bullocks are driven by one man by means of ordinary reins. The cattle walk round at a quick pace and with freedom. Sometimes the bullocks are driven yoked to a cart. The pressure of the wheels helps to separate the grain. The question may be seriously asked whether these old-time methods are not now antiquated. Under the existing conditions of Indian agriculture, I am afraid they are not. One can, of course, point to the speedier, cleaner work of steam threshers and winnowers in more advanced countries, but one also should remem-

ber that the flail for threshing and the hand riddle for cleaning and sifting were in these countries very much in evidence not so many years ago. They did good work in the hands of expert labourers. The ordinary field labourer in India is also expert at threshing and winnowing in his own way. The hard up cultivators of small holdings cannot afford to change their methods. Such threshing and winnowing machines as have been introduced into India have not kept in effective working order long. Owing to the excessive heat, the wooden parts warp, and the iron parts get out of proper bearing.

In Madras, especially in the Bellary district, ordinary stone road rollers are used for threshing *jowár*, and do effective work.

In Gujarát wheat is threshed with a machine, the action of which is, to some extent, similar. The wheat thresher of Gujarát consists of a series of iron toothed discs, keyed on three spindles which are fixed like axles in a frame. The discs are so placed on the spindles that no two follow in the same track. A man sitting on a seat above the frame drives two bullocks which drag the thresher round the grain pile. The discs act as wheels to the thresher, and, in revolving, thresh out the grain, and at work not only do so, but bruise or cut up the straw into *bhusa*. The stone roller, on the other hand, is used merely to crush out the grain from the heads of *jowári*. At first sight, it would appear that the weight of the roller would damage the grain, but such is not the case. This method of threshing, doubtless, has its advantages in economizing bullock labour at a season when it could be economically employed in ploughing fields which have become infested with *kunda* and other deep-rooted weeds. Such ploughing to be effective must be done in the fair season and preferably at that season when the work cattle are usually employed at that long, tedious operation—"treading out the corn."

Winnowing

Hot winds begin to blow in the Deccan in March, and then grain is mostly prepared for market. A steady wind of fair strength is best for winnowing. The threshed grain and chaff are carried by means of a *sup* or basket to a man who stands on a stool, and who allows the grain and chaff to drop in a steady stream from a height of 8 ft. (from a lower height, if the wind is strong). The grain with earth particles drop straight down. Dust, chaff and all light materials are carried some distance by the wind. A man or woman sitting under the stool (*chakur*) gives the grain a finishing touch by brushing away such impurities as can be separated by means of a broom made from the culms of a grass called *bokhri*. A broom made from thin stalks of *tur* or cotton does equally well for the purpose.

Outturn. An average crop in the Deccan will vary, according to the quality of soil, from 500 to 900 lbs. per acre of *jowár* and 100 to 200 lbs., subordinate pulses with 350 to 450 bundles of *kadbi*.

The *kadbi* is invariably sold by the 100 bundles. By custom 106 bundles are counted as 100. The price is regulated, to some extent, by the size of the bundles, by the quality of the *kadbi*, and the season when sold. A small bundle weighs about 3 lbs., a large bundle 7 or 8 lbs.

Cultivation of Kharif Jowár in Gujarát.

The cultivation of *kharif jowár* in the Surat District may be taken as illustrative of its cultivation in many other parts of the Presidency. There, on black soil, it generally alternates with cotton. The cotton stalks are removed, and the land repeatedly harrowed or scarified in April and May. If the land is fairly clean, no ploughing is required, because *jowári* likes a firm seed bed. On the *gorádu* or sandy soil of Northern Gujarát ploughing is necessary, not so on black land. If the land is weedy, two light ploughings are given when the soil is moist after rain. A favourable seed bed is prepared by the subsequent use of the harrow.

In June or early July the seed is drilled in rows about 20 inches apart. The light two-coultered drill, with coulters set 28 digits apart, is used. The seed rate depends upon the proportion of subordinate pulse mixture (*kathol*) sown. Ordinarily the following figures will represent seed rate, and produce, under average circumstances, on good black land :—

	Seed per acre.	Produce per acre.
	Lbs.	Lbs.
Jowári	6	700—900
Tuver	2	150—200
Chola	¼	Eaten as green vegetable.
Mag	1	60—80
Ambádi (Sheria)	Sprinkling.	Fibre for ropes.
Tal	¼	40—60

After the drill, a light harrow follows to cover the seed and level the surface. Sometimes the *samár* (plank roller) is used for the latter purpose. When the crop stands about 9 inches high, the bullock hoe is used for inter-culture, and immediately afterwards the crop is hand weeded. Superfluous seedlings are removed by hand. Ten days afterwards the bullock hoe is again used, and, if necessary, another hand weeding given. Subsequently, the plough is passed between the rows. This breaks up the surface into rather rough lumps, and tends to conserve moisture in the soil. No further attention, except watching, is required until the crop is ripe. The principal crop is ready about five months after sowing. It is reaped

with a sickle, and usually a long stubble is left. The stalks are laid neatly into bundles. These are bound up three or four days afterwards, when the heads are removed and carted to the threshing floor. The bundles (*pullas*) are stacked when quite dry. 350 to 450 bundles of *kadbi* are usually got from an acre.

Cultivation of Rabi Jowar in Gujarat.

In the Broach District, north of the Nerbudda, *rabi jowár* is extensively grown. There the black soil is deeper than that of Surat, and although the rainfall of Broach is not particularly heavy, the depth and density of the soil retains sufficient moisture to favour the growth of *rabi jowár*.

In Broach, *shiálu jowár* is drilled in September or October. The preparatory tillage is one or two ploughings and repeated harrowings. The seed rate is 7 or 8 lbs. per acre. The rows are about 20 inches apart. The drill used is the heavy two-rowed drill, with coulters 28 digits apart, which leaves the surface soil in rounded ridges and shallow furrows. The rows of crop occupy the furrows ; this is an obvious advantage. Sufficient moisture is thus got to secure germination without burying the seed too deeply, and the practice might well be imitated elsewhere. The crop is twice inter-cultured with the bullock hoe, once before and once after the *samár* is used upon it. The *samár* is worked across the rows, and the object in using this leveller is to fill up the cracks in the soil. As the ears begin to fill, the stalks are tied up to each other, so that they may not be lodged. This is only necessary in a good year with a good crop. Harvest usually comes in February or March, five and a half or six months after sowing. The ears are first cut off the standing crop, and then after a few days the stalks are pulled by the roots. The stems are ordinarily 4 to 6 feet high. An acre produces 800 lbs. to 1,000 lbs. grain and 300 to 400 bundles of *kadbi*, each bundle weighing 4 to 6 lbs. The fodder is usually of excellent quality, because the crop stands farely thick upon the ground and the stalks are neither very tall nor very coarse. A *rabi* crop in other black soil districts yields generally in a fair season 550 lbs. to 700 lbs. per acre.

Diseases and remedies.

Jowári is subject to several diseases. When young, it is attacked by aphides (*mowa*). It is subject to rust—not, however, the true wheat rust. The fodder is thereby deteriorated, but it is doubtful if the outturn of grain is much lessened. Aphides and rust appear when there is continued cloudy wet weather and in ordinary seasons. With a fair proportion of sunshine, little or no injury is done by these attacks. A fungoid disease allied to both smut and bunt, without the greasy

appearance and smell of the latter,' is common in both *jowár* and *bájri*. It is called *angaria* in Gujarát. This disease and other fungoid diseases owe their origin in part to diseased germs which contaminate the seed. The germs can be destroyed by steeping the seed before sowing in sulphate of copper (½ per cent. solution) or in water at a temperature of 135° to 150° F. The hot water treatment is the simplest, but not so effective as the sulphate of copper. Boiling water and well water at any ordinary temperature, if mixed together in equal proportions, will give water sufficiently hot, but not too hot, for the purpose. The temperature will ordinarily range from 135° to 145° F. The results noted below were obtained at the Surat Farm in 1898-99—a bad year for smut in *jowári*. They show unmistakably the value of steeping seed before sowing.

	Number of smutted cars per acre. Unsteeped plot.		Number of smutted cars per acre. Seed steeped in ½ per cent. copper sulp. solution.		Number of smutted cars per acre. Seed steeped in hot water.	
1898-99.	1st plot. No.	2nd plot. No.	1st plot. No.	2nd plot No.	1st plot. No.	2nd plot. No.
Smutted cars	200	329	23	18	61	59

Stale urine is sometimes used as a preventative for this fungoid disease. It should be poured over the grain, and powdered quicklime afterwards used for drying.

The sugar borer (*gabra*) is often destructive in *jowári* fields. As far as is known, the life history of this pest is given in the account of sugarcane cultivation, as well as the remedies. *Jowári* affected with *gabra* is supposed to contain a poisonous principle not well understood. It is known that young shoots of *jowári* and young plants which have withered prematurely owing to drought are dangerous if used as food for farm animals.

A vegetable parasite (*tavli*), *Striga hirsuta*, attacks sugarcane and *jowári*. Its fibrous roots entwine round the roots of the crops named, and check their growth. The crops become pale and patchy in appearance where *tavli* occurs. The parasite grows rapidly, and frequent weeding is the only remedy. (*See* description under sugarcane.)

General Characteristics of Jowari.

Large number of varieties cultivated.

Over one hundred and twenty distinct varieties of *jowár* have been identified throughout the Presidency. All have been grown side by side on the Government farms. Detailed descriptions of each variety have been taken, but it will take years of patient investigation to determine accurately the true economic value of each variety. The number of varieties in general cultivation throughout India is probably very large.

Kharif and rabi varieties.

The most noticeable differences between varieties are that *kharif*,

i.e., rain crop or early varieties are much more numerous than *rabi* or late varieties. Early and late varieties do best if sown at their appropriate seasons. A *rabi* variety may or may not thrive if sown as a rain crop. None of the rain crop varieties are likely to succeed if sown in the *rabi* season.

Development varies with season, soil, &c.

The development of the plant as regards length and stoutness of stalk and size and weight of grain head depends more upon the character of the season, the kind and condition of soil, and the methods of cultivation than upon differences between varieties.

Thick and thin sowing.

If the seed of any variety is sown thickly in good, well manured soil in a favourable season, the stalks will grow tall and thin, and produce small heads of grain. It cannot, therefore, be said that any variety grows to a particular height and produces heads of grain of a particular weight and size. There are, however, other characteristics that are perfectly constant.

Tillering.

None of the varieties examined have any decided tendency to produce more than one shoot from one root. Numerous shoots from one root indicate a check in the early stages of growth or a diseased condition. Thus if the leading shoot is attacked by the sugar borer, several side shoots will grow. In some varieties a much more vigorous growth springs from the stubble of a reaped crop than in others.

Heads of grain.

Generally, each single stalk produces one head of grain ; but in some varieties the principal stalks have side-shoots which each produces a head of grain which is smaller, and ripens later than that on the main stalk. Supposing the plants of each variety stand sufficiently far apart for natural and full development, then the heads of grain in some varieties are very much larger and heavier than in others. The natural weight of heads of grain may range from 2 *oz.* or less to 1 lb. or more.

The heads of grain in different varieties vary in shape and general construction in remarkable degrees. They may be dense and hard, or more or less open and loose, the extreme limit in this respect being a very hard, densely packed, conical head and a much branched, drooping, graceful panniele. The peduncle which carries the grain head may be upright or bent or drooping. It may be short, of medium length, or long. A heavy head of grain has generally a drooping peduncle, and is supported on a short or moderately short stalk which is coarse and fibrous, and has usually aereal roots which give support when they attach themselves to the soil. A variety with a small head of grain or a much branched panniele has usually a thin stalk and straight peduncle.

The fodder.

There is no doubt that the stalks of some varieties are, when ripe, far more nutritious than the stalks of others. In gauging the value

of the stalks as fodder, count should be taken of the length and fineness of stalk, sweetness, freedom from coarse fibre, number of side leaves, and whether such remain green as the plant approaches maturity or wither up much earlier. As regards all these points there are considerable differences between varieties, and it will take a good deal of careful enquiry to determine definitely which are the best grain and best fodder varieties for various descriptions of soil and climate.

Early and late varieties. Some varieties mature much more quickly than others. It is important to know which varieties reach maturity earliest, because, after a period of scarcity or famine, varieties which produce grain and fodder in the least time would be most in demand.

The grain or seed. There is great variation in the grain of different varieties in colour, size, shape and weight.

The best grain varieties have white or creamy white grain (excepting the apex or point which in all varieties is dark in colour). In fine varieties the grain has often a pearly lustre. It should be plump and rounded. In a very good sample 220 to 230 grains will weigh a *tola*. The range between good and inferior varieties in this respect is from 220 to over 1,000 grains per tola. In all varieties the grain is more or less flattened near the apex on one side, but in some varieties the flattening is considerable. This gives a hooked appearance to the apex. Again, in some varieties the grain is curiously indented. Such varieties are those most in request for parching, unripe ears being thus cooked.

In many varieties the grain, though of definite general colour, is blotched or spotted with red or brown spots in a very irregular manner. In a few varieties the colour of the grain can only be described as dirty.

Grain may vary in colour from pure white through all the shades of yellow and mahogany red to a dull amber or brown.

Glumes. The glumes in some varieties are not well developed, and the grain is insecurely enclosed. In other varieties they are much more prominent, whilst in a few they completely enclose the grain and adhere to it.

The colour of the glumes may vary from pale straw through khâki and drab, red and red brown to dark brown and black. The glumes may be shining or flossy. Small awns may be abundantly present or the reverse. Some glumes have a feathery appearance.

Varieties suitable for irrigation. Only a very few varieties of *jowâri* are suitable for cultivation under irrigation, particularly if sown late in the cold season or during the hot weather.

Green fodder. All varieties yield the best fodder when the plant is in full flower or when the grain has begun to form. It is probably safest to cut the crop for green fodder at the latter stage, because it is dangerous to feed very young *jowâri* to farm animals. The tendency of such fodder to

cause typanites is well known, but there are other risks which are not so well understood. Such varieties as have heads of grain in the form of much branched pannicles afford no foothold for birds, and such crops require little or no watching. If the grain is closely encased in the glumes, this proves another safeguard. Damage by birds.

Jowári and other grain is stored for years in the Deccan in underground pits or *pevs*. The manner of storage is fully described in the chapter on ensilage. Storing grain.

Cost of cultivating Jowár with Subordinate Tuver after Cotton, Surat District.

	Per Acre. Rs.	a.	p.
April.—Digging and collecting cotton stalks	1	2	0
Do.—Harrowing once with *karab*	0	8	0
May.— Do. 2nd time do.	0	6	0
Do.—Collecting and burning roots of cotton	0	2	0
June.—Ploughing with light plough (*hal*)	1	3	0
Do.—Digging corners and headlands	0	3	0
Do.—Once harrowing	0	4	0
July.—Sowing by drill and covering seed	0	9	0
Cost of seed 9 lbs. *jowár* / Do. 3 lbs. *tuver*	0	5	0
July-August.—Hand weeding	1	4	0
Do.— Thinning out plants	0	7	0
Do.— Inter-culture with bullock hoe twice ...	0	7	0
Nov.-Dec.—Watching—1 woman, 2½ months, 4 acres ...	2	0	0
Dec.—Harvesting *jowár*, tying bundles and stacking in field	1	4	0
Cutting and carting heads of grain to threshing floor and re-stacking bundles in field	1	2	0
Jan.—Threshing and winnowing	1	2	0
Harvesting *tuver*	0	6	0
Carting, threshing and winnowing	0	8	0
Rs. ...	13	2	0

The following would be the outturn of a crop on which the above expenditure was incurred :—

Grain. Per Acre. Lbs.		Fodder. Per Acre. Lbs.
Jowár 850	*Jowár* Bhusa	270
Tuver 220	*Tuver* do.	240
	Bundles *Jowár Kadbi* ...	400

Sorghums as Fodder Crops.

Of the numerous varieties of *jowár* which have been identified, only a few are specially suitable for the production of fodder.

The best are *sundhia*, *dudhia*, *nilva*, *utávli*, two varieties of American sorghum, imphee or African sugarcane, *hundi* and *kálbondi*.

Sundhia. The *sundhia jowâri* is probably the best fodder variety in cultivation. It grows to perfection in its own district (Northern Gujarát) on the deep, alluvial, sandy or sandy loam soils, either as a rain crop or under irrigation in the hot weather. In other parts of the Presidency as a *kharif* crop it appears to thrive on almost any description of fairly good soil, with a moderate, well distributed rainfall. It grows excellently on medium black soil, but in the Deccan only does moderately as an irrigated crop either in the cold or hot seasons.

There are two varieties—*farfaria* and *amaria*—very similar in appearance. The latter has a denser head of grain with a tendency for the peduncle to curve slightly, so that the head of grain droops slightly. The stalks are somewhat stouter than those of *farfaria*. The head of grain in each case is a much branched panniele. The side leaves are not very numerous, and often, like the stalks, are discoloured by red blotches like those caused by rust. The crop is apt to lodge in heavy rain, if sown thickly. Both varieties grow with great rapidity under favourable conditions. The grain is inferior as a bread corn. The seed rate should be high—50 to 60 lbs. per acre—and, to secure even distribution, should be broadcasted by hand in the furrow behind a plough, the soil having been previously worked to a fine friable condition. Even distribution of seed is also secured by using a 4 coultered seed drill, first lengthwise and then across the field. The coulters should be about 12 inches apart. Two seed drills should be used simultaneously—one lengthwise, the other across, because then the field is finished more quickly, and there is less risk of the cross sowing being interrupted by rain. Large fields should be sown in sections.

A good crop when in flower should stand very dense, and be 9 feet to 11 feet high. In a crop of this sort the stalks are no thicker than strong wheat straw, and can be fed to cattle with no waste.

Dudhia. *Dudhia* is a variety common in the Kaira and Baroda *goráda* soils. The head of grain is small and dense. In other respects *dudhia* has much the same habit of growth as the *sundhia* varieties, except that the stalks are somewhat coarser. It is usually grown mixed with *sundhia* in the Kaira and Baroda Districts.

Nilva. *Nilva* is the best Deccan fodder variety for a monsoon crop. It is also grown for grain, but its chief cultivation is near populous centres where fodder of fine quality is specially valuable. It has a small, moderately dense head of grain, with dull coloured, rather inferior, seed. It does not require so high a seed rate as *sundhia*, 40 to 45 lbs. per acre being sufficient for a dense crop in fertile soil with sufficient rainfall. It does best on medium black soil. *Nilva* has more leaf growth than *sundhia*, with rather thicker stalks, but does not mature so quickly.

The stalks in a dense crop are in no wise coarse, and there is no waste in feeding the fodder. If *nilva* is cut green, and a fair stubble is left, a second and third cut in the same season may be obtained if rain is favourable or irrigation is given. This is a valuable characteristic, common to some varieties of *jowári* only. A thick sown crop does not withstand extreme wet weather or prolonged drought, as well as a thinly sown crop; but in the Deccan this variety does not yield to adverse conditions of soil, climate, &c., so easily as *sundhia* does or such other varieties as are not purely indigenous. It has by acclimatization become inured to conditions of climate often unfavourable, and therefore withstands them. *Nilva* under almost any circumstances in the Deccan will yield a greater outturn of fodder than *sundhia*, but I should value the fodder of the former at a lower rate, because the stalks are coarse and woody in slight degree.

Utávli is another good Deccan variety. It grows more quickly than *nilva*, and is particularly suitable for sowing midway between the *kharif* and *rabi* seasons. It does very well on moderately light soil, also on medium black; but a heavy crop need not be expected unless the soil is in good condition. As a cold weather irrigated crop, *utávli* does better than *nilva*. It requires the same seed rate as *nilva*. The stalks in a good dense crop are tall and thin but in a thin crop the stalks are thick and woody. The head of grain is a moderately open panniele, carried generally erect. This variety is recommended, if, for special reasons, it is necessary to sow a fodder crop in August or September. Utávli.

American sorghums.—Two American sugar sorghums were introduced by the Bombay Agricultural Department several years ago. They bear favourable comparison in the Deccan with the foregoing varieties as fodder crops. These varieties are similar in every respect, excepting that in one black and in the other yellow brown glumes enclose the seed; hence the names Collier and Amber. These sorghums grow rapidly, and do best as rain crops on medium black soil. When sown thickly, the stalks are thin. 50 lbs. seed per acre should be sown. There are numerous side leaves which keep green when the seed ripens. The grain head is a much branched, very graceful, drooping panniele, affording, like *sundhia*, no foothold to birds—an obvious advantage. The grain, though inferior in quality, is plump and large. These sorghums are grown in America as sugar crops. They were found on trial not to answer as such in India, but the percentage of sugar which the ripe stalks contain adds to their feeding value, though sugar in quantity is not a safe food amongst breeding animals, as it tends to impair fecundity. Two American sorghums.

In a favourable season, on good, fairly deep, free working soil, well stocked with manure, the sorghums will yield as heavily as the best indigenous varieties ; but with deficient rainfall, or other unfavourable condition, or on light poor soil, or as irrigated crops, they do not in the Deccan succeed so well as *nilva* or *utávli*.

Imphee. *Imphee* as grown on the farm may be classed as a near relative of the American sorghums, but does not yield so satisfactorily. The American sorghums and imphee, like *nilva*, if cut green, send up in favourable weather a second and third growth, the third growth being diminutive.

Hundi and *kálbondi*. *Hundi* and *kálbondi* are recommended for cultivation as irrigated crops, and should be sown any time between November and February. None of the finer varieties referred to above as suitable for cultivation in the rains can be grown successfully on mixed black soil in the Deccan under irrigation. No other crops can compare with the sorghums in yielding a heavy weight of green fodder of good quality. Succulent fodder of this class is specially valuable in the hot weather for all farm animals, and *hundi* and *kálbondi* are the most suitable varieties yet found for the purpose. There is little to chose between them. They do best on medium black soil of fair depth, with *murum* 2 to 3 feet below the surface. The stalks of each are tall, but rather coarse and woody. The field must be well tilled and well manured with old, thoroughly decayed manure to give the best results. Beds 10 feet square should be formed for irrigation. The seed, about 40 lbs. per acre, should be evenly broadcasted by hand, and covered with a long-toothed wooden hand rake. If weeds appear, hand weeding is necessary. Irrigation is required every ten days in the cold weather and every eight days in the hot weather. Both these crops, if they are cut for fodder before they reach maturity, send up a second growth which is often a very good crop if a stubble of 2″ or 3″ is left. Several stalks spring from one root stock.

Sowing. The methods of sowing the rain crops has already been referred to. The broadcast method behind a plough is certainly the best, but it is slow. A small country plough should be used. The seed sown in a furrow is covered by the soil moved by the plough in making the next furrow. The furrows should not be more than 8″ wide. The plough should work not more than 3″ deep, otherwise the seed will be buried too deeply and will not germinate. Two women sowing can keep up with one plough, working as fast as an ordinary pair of bullocks can walk. A harrow with the prongs and blade removed should be worked after the plough to level and smooth the surface. These methods of sowing thickly either by drill or broadcast behind

the plough will only succeed in clean, well-tilled ground. The seed is sown so thickly that the field cannot be weeded by bullock hoe in the ordinary way, and the young plants being very close together, hand weeding with a *khurpa* (weeding hook) is difficult to do and very expensive. It is well to postpone sowing until the monsoon has somewhat advanced. The land should, however, be worked after the first fall of rains, and then left until the annual weeds germinate. One turn of the harrow in fine weather will destroy these, and then sowing may be proceeded with. *Sundhia* is in full flower and ready for cutting as fodder in 65 to 70 days after sowing, the sorghums and *utávli* in 75 days, and *nilva* in about 80 to 85 days.

Outturn results.

The following are excellent outturn results from *nilva* and *sundhia* obtained in a favourable year on the Poona Government Farm. The crops were grown after lucerne which had been heavily manured from time to time. The soil was in excellent condition and in good tilth.

	Green Fodder. Per Acre. Lbs.	Value of Outturn. Per Acre. Rs.	Rate per Rupee. Lbs.
Nilva	32,548	108·8	300
Sundhia	26,766	107	250

We have repeatedly grown at the Poona Government Farm over 30,000 lbs. per acre of green fodder from *nilva* and the two American sorghums. None of the fodder varieties of *jowár* or sorghums can be grown continuously on the same land year after year. They become unhealthy if so grown. They should either be rotated with another good rotation crop, or they should be sown mixed with one or other of the various pulses. The sorghum fodder crop with subordinate rows of pulse can be grown continuously for a good many years on the same field without any harm being done. The practice on the Farm is to sow every fourth row with pulse. The pulse, as well as the sorghum, can be cut green as fodder. The best pulses for the purpose are *kulthi* on light soil, and *mug*, *cholá*, *udid* or *vál* on heavier soil. The mixed pulse and sorghum fodder is for feeding purposes superior to either fodder alone. Both *vál* and *cholá* grow very well also in the fair season under irrigation. Such crops in the farm have yielded—

Suitable rotation for fodder varieties.

Vál ... ... Lbs. 10,260 per acre green fodder.
Cholá ... ... „ 15,240 „ „

A rain crop of sorghums and an irrigated fair weather crop of pulse would form a good rotation, and could be continued on good well manured land for several years without either crop becoming unhealthy.

BULRUSH MILLET—*BÁJRI*—*Pennisetum typhoideum*, sometimes called *Pennicellaria spicata*—Willd.

Natural order—*Gramineæ*. Tribe—*Paniceæ*.

This cereal is widely cultivated in Asia and along the northern seaboard of Africa. It is probably of African origin. It is not so generally cultivated in hot countries throughout the world as its more common companion millets of India. In England it is called spiked or bulrush millet. The latter name is given on account of the resemblance in shape of the spike of *bájri* to the head of the common bulrush. Throughout the Bombay Presidency, and generally throughout India, it is commonly known as *bájri* or *bájra*. In Madras it is called *kumbu*.

Botanical Description (Professor Gammie).

Pennisetum—Rich. *Inflorescence* a large, dense, cylindric spike; *spikelets* surrounded at the base by persistent, weak bristles.

Pennisetum typhoideum, Pers. Bulrush millet.

Vern., *Bájri*.

An erect *annual*, 3 to 8 feet high. *Stem* solid, simple or branched, often stout, leafy, upper joints smooth or woolly, lower rooting. *Leaves*, large, spreading and drooping, with a few bulbous hairs near the base; *sheaths* moderately loose, closely furrowed, smooth; *ligule* of white densely-packed hairs. Stalk of the inflorescence more or less woolly below the spike. *Spikes* up to a foot long and one and a half inches broad, erect; *axis* woolly; *spikelets* in clusters of 1 to 8 on separate stalks, which are concealed within the continuously densely packed inflorescence; *bristles* unilateral, varying in colour, inner ones plumose, all as long as the spikelets or some longer; *first* and *second glume* minute, *third* and *fourth* subequal, with large *pales*. *Grain* obovoid, white, protruding from the glume and pale.

Distribution in the Presidency.

Bájri is entirely a rain crop, and occupies the lighter descriptions of soils in all districts of moderate rainfall. Throughout the Deccan *bájri* is extensively cultivated on shallow, mixed black, red and lighter coloured stoney soils found on sloping ground, the lower lying, deeper, more fertile soils, as well as the more open black soil plains being chiefly occupied by *jowár*. In Gujarát the cultivation of *bájri* is most important in the sandy (*gorádu*) soils of Kaira and Ahmedabad. These districts grow, respectively, about 240,000 and 200,000 acres annually. Panch Mahals has 50,000, Broach 15,000, and Surát only 7,000 acres. In the two latter districts *bájri* is

grown chiefly on the sandy coast belt. In the Deccan in ordinary years *jowár* and *bájri* occupy about equal areas. Ahmednagar has 1,000,000 acres; Khándesh, Násik and Poona about 600,000 to 700,000 acres each; Sátárá 600,000; and Sholápur 250,000. In the Karnátak *bájri* when compared with *jowár* is not such an important crop. Bijápur in a good year grows over 300,000 acres, Belgaum 150,000 acres, and Dhárwár about 6,000 acres.

In most of the Presidency districts the *jowár* and *bájri* areas fluctuate considerably from year to year. In years of heavy, early rainfall *jowár* will occupy a more extended area than when the monsoon is deficient or late. The latter conditions may not be unfavourable to *bájri*.

Climate.

Bájri does best when the climate is moderately dry and when the monsoon rain comes in light downpours and there is plenty of sunshine between showers. Heavy rain is disastrous to germinating seed or young seedlings, and later, when the crop has made some progress, it is checked in growth and turns yellow during heavy continuous rain. It is easier injuriously affected in this way than any other *kharif* cereal. If heavy rain comes as the inflorescence is in flower, the pollen is washed away, and many of the female flowers are not fertilized, and therefore the heads of grain are partially empty. In the Deccan the sowing of *bájri* is purposely delayed until the middle of July in order to avoid, as far as possible, the risks referred to above.

General characters of the plant.

On well manured or rich soil *bájri* tillers extensively. In the Deccan usually one spike is carried on each stalk, but in the fertile soils of Gujarát it is common to find several lateral shoots from one stalk, each lateral shoot bearing a small spike. The straw in Gujarát is of fairly good quality. It is readily eaten by work cattle and even by highly fed milk buffaloes. The straw of *bájri* in the Deccan from a ripe crop is considered of poor nutritive quality, and all kinds of farm animals prefer almost any other description of fodder to *bájri* straw. The inference is that the straw of the *Deshi* variety of Gujarát is better in quality than the straw of the Deccan variety.

Rotations and mixtures.

Except in parts of Khándesh, *bájri* is always a mixed crop; and as a mixed crop it may be grown on the same land continuously without any apparent exhaustion of soil or diminution of outturn if the cultivation is fairly liberal. On the other hand, it is often rotated. In the lighter soils of Khándesh it is considered a good preparation for Varádi cotton. In the sandy

soils of Kaira, Ahmedabad, &c., it is rotated with *kodra*, *sundhia*, *jowár*, &c. In the light soils of the Deccan it is rotated with *jowár*, niger seed, &c.

In the Deccan the subordinate crops sown with *bájri* are separate rows of *tur* (usually every 4″ row) and a sprinkling of *udid*, *math*, *kulthi*, *ambádi*, &c., in the rows of *bájri*. Sometimes separate rows of *khurásni* take the place of those of *tur*. The most common, subordinate mixture in Gujarát is perennial, *rozi* cotton in rows and *math* as a sprinkling in the *bájri*, but two or more of the following crops may also be grown subordinate to *bájri*, *viz.*, *mag*, *chola*, *udid*, *guvár*, sesamum and *sheria*; the *tuver* always in separate rows, the others as a sprinkling.

Five varieties of *bájri* have been identified in the Presidency. They are shortly described as under :—

Giant *bájri*, called Jabalpuri, and in the Kaira District, Bhávnagari indicating presumably the districts whence the variety was first obtained.

Varieties. This variety has coarse stalks and long thick spikes of large grain. It requires good land in good condition and a favourable season with well distributed rainfall. It gives poor results in light, unmanured soil in a poor season. In a really good crop the best spikes are a foot or more in length. Professor Gammie says the grey, purple bristles equal or slightly exceed the spikelets in length.

Málbandro or *Madhodri*.—The straw is finer than that of *bájro*, the stalks being thinner. This probably is an offshoot from the *Deshi* variety of Gujarát. It has longer spikes and larger grain than the *Deshi*. The cultivation of this variety was confined until recently to Boriávi, a fertile village of the Kaira District. Professor Gammie says this variety differs from giant *bájri* in the grey, purple spikes being thinner and shorter and in having more membranous glumes.

Nadiad *bájri* or *Deshi* variety of Gujarát is, perhaps, more vigourous in growth than *Málbandro*, but the spikes are thinner and shorter, and are dull, light brown. The upper parts of the stem are inclined to branch. (Gammie.)

Awned *bájri*.—This variety is sparingly grown near Petlád in Gujarát and in the Ahmednagar District. The spikes have a hairy or bristly appearance after the pollen is shed. There is one bristle on each pedicle, about ½ inch in length or twice the length of the spikelets (Gammie). The bristles are rich, purplish-brown in colour before the crop is ripe. This gives a characteristic appearance. They become tawny or smoky-brown in the ripe crop. They are more developed in some heads of grain than in others, and, to some extent, protect the head of grain from birds. This is an obvious advantage. The straw is tall and

somewhat coarse. The head of grain is long, and, owing to the bristles, look thick. The seed is smaller than that of the Gujarát varieties, but bigger than the ordinary Deccan variety. The presence of bristles may indicate a more recent advance from the wild form than other cultivated varieties, but the superior quality of the seed does not substantiate this supposition.

Deccan *bájri*—The straw of this variety is not nearly so tall as other varieties. The spike of grain is short, thin and contains small seed. It is a hardy variety which resists unfavourable conditions better than other varieties. The straw is inferior fodder.

CULTIVATION OF BA'JRI IN GUJARA'T—(SANDY OR GORA'DU SOIL IN THE KAIRA DISTRICT).

The land should be ploughed with the light *hal* two or three times after the first fall of rain, and then left for some time. The field should be again ploughed or worked with a bladed harrow shortly before sowing. This working will destroy annual weeds, and leave the soil in fine tilth for sowing. The seed should be sown between the 1st and 15th of July. Generally, sowings about the latter date are more successful than those sown earlier. The seed rate mixture for an acre may consist of the following :—

	Per Acre.	
Bájri	6 lbs.	Mixed together before sowing.
Guvár	1 lb.	
Math	1 lb.	
Mag	½ lb.	
Sesamum	½ lb.	
Ambádi or Sheria	½ lb.	
Tuver	1½ to 2 lbs.	Sown separately in every fourth row.

Usually not more than two pulses with sesamum and *sheria* are sown subordinate to *bájri*, in which case the pulse seed rate is higher than above, and the *bájri* seed rate is 8 lbs. per acre. The seed is drilled usually with a 3-coultered drill (*tarfin*), the rows being about 15 in. apart. The *samár* (plank roller) is used after the drill to smooth the surface and properly cover the seed. As soon as the young seedlings are fairly strong and about 6″ high, the crop should be bullock hoed with the *karabdi*, and such weeds as are not destroyed by the bullock hoe should be hand weeded with the *khurpi* (weeding hook). The bullock hoe should be used a second time before the crop is 2 feet high. The *samár* (plank roller) is put sometimes over the crop about this time, the object being to check the growth of the plants and thereby encourage tillering. The final tillage operation is to pass the 3-coultered seed drill (seed bowl and seed tubes removed) between the rows. Each tine or coulter works midway between two rows, grubs up the soil, and throws up the

earth about the rows of *bájri*. The light plough does the work better, but not so expeditiously. No further attention is required except watching to prevent damage by birds until harvest time. A crop which is sown early in July will be ripe early in October. *Tal* (sesamum) is generally ripe before the *bájri*. The pulses ripen later, but it is a common practise to pluck the pods of some of the pulses earlier as green vegetables. The mixed crop is in average seasons safer and more remunerative than *bájri* alone. In a year of fairly heavy rainfall the pulses (particularly *tuver* and *guvár*) will do well. In a year of light rainfall after July the *bájri* may thrive so well and grow so freely that the subordinate crops may be partially suppressed.

Harvesting and threshing.

Bájri is reaped with a sickle and close to the ground. It should be left lying in the field for several days, then bound into bundles and grain and straw stacked, or the heads of grain may be removed and carted to the threshing floor, and the bundles of *kadbi* only stacked. An idea prevails in Gujarát that *bájri* when reaped should lie two days in the sun and then be stacked. If left in a stack for a week, the sap is supposed to be carried to the heads, and the grain thereby becomes improved. Grain which has been stacked is easiest threshed. The ears of grain are removed by women using small sharp sickles. The work is slow and costly if done by hired labour. A woman can remove the heads of grain from about 70 bundles per day. In treading out the crop, the heads of grain should be heaped on the threshing floor to a depth of 9″, and frequently stirred with a rake during the threshing process.

Outturn.

The outturn of *bájri* in comparison with the subordinate mixture depends entirely upon the character of the season. In a season alike favourable for *bájri* and the subordinate mixtures, a well managed field in the Kaira District may yield as under :—

	Seed-rate. Per Acre. Lbs.	Outturn. Per Acre. Grain, Seed or useful By-Product. Lbs.
Bájri	6 to 8	900
Math	1 to 1½	120
Guvár	1	80
Sesamum	¼	60
Sheria	½	Fibre.

The combined weight of *bájri* straw and pulse fodder may vary from about 3,000 lbs. per acre to 50 per cent. more.

Selection of seed for next year's crop and storing it.

It is advisable to select at harvest time the largest best filled heads of grain for seed for next year's crop. These heads should be threshed on a small, clean, new threshing floor which cannot possibly harbour weevils. The seed as soon as it is threshed should be put mixed with ashes in clean, earthenware jars. The mouth of each jar should at

once be plastered over with cowdung and mud. These remarks apply with equal force to the selection and storing of seed of all other crops.

Cost of Cultivation in Gujarát.

	Per Acre. Rs.	a.	p.
Manure, 10 loads per acre	5	0	0
4 Ploughings with light *hal*	3	0	0
2 Harrowings and 1 turn of *samár*	0	9	0
Sowing and covering seed with *samár*	0	7	0
Cost of seed (*bájri* and mixture)	0	6	0
Twice bullock-hoeing	0	7	0
Hand-weeding	1	4	0
Ploughing between rows	0	8	0
Watching—1 woman, 1½ months, 4 acres	1	8	0
Harvesting various crops; tying bundles and stacking in field	2	6	0
Cutting heads from *bájri*; carting to threshing floor ...	1	12	0
Threshing and winnowing *bájri* and subordinate crops ...	1	14	0
	19	1	0
Add Government assessment	7	0	0
Total ...	26	1	0

Cultivation in the Deccan.

The field is very often prepared with the heavy bladed harrow (*vakhar*) only. It is worked two or three times in April and May and again when the soil is sufficiently moistened by monsoon rain. Thus a friable, smooth seed bed, about 3 in. deep, is prepared.

A good cultivator will, however, plough his field well, and give such dressing of manure as he can afford, particularly if the soil is moderately good and fairly deep. There is plenty of time for ploughing and thorough tillage, as *bájri* is rarely sown in the Deccan before the middle of July. If sown earlier heavy rain is apt to fall at flowering time, the effect is that fertilization is not properly completed, and the spikes are, when ripe, only partially filled with grain. The seed is drilled with the 4-coultered seed drill, and the rows are about 13″ apart. The crop is hand weeded on good land, but this expensive operation is not done on poor, upland, light soil fields. The bullock hoe, (*kolpa*) is worked generally two or three times. The crop ripens in October. The cost of cultivation is much less in the Deccan than in Gujarát. The Deccan crop does not yield anything like the outturn got from the fertile soils of Kaira. The Deccan soils vary so much that it is impossible to give averages.

Diseases.

Bájri is subject to the same insect pests as *jowár* and also to rust and smut (*angaria*). These diseases are referred to under *jowár*. It is common to find in *bájri* a malformation caused by the flowers giving rise to vegetable shoots.

WHEAT, *Triticum*.—Linn.

Annual, tufted. *Stems* up to 3 ft. high, joints swollen, hairy. *Leaves* almost smooth, with a hairy fringe at base, up to 12 in. long; *sheaths* smooth above, often hairy beneath. *Spikelets* arranged in a two-ranked, cylindric or subquadrangular column, few flowered, compressed, stalkless and seated in notches of the axis with which they are parallel; *glumes* keeled, awned or awnless (bearded or beardless); top of ovary hairy. *Grain* grooved on the inner face, often hairy, free or adherent to the pale.

The following forms are said to be cultivated:—

1. *Triticum Spelta*, Linn. Covered grain wheat.
   Vern., *Khapli; jod.*
2. *Triticum vulgare*, Vill.
   Vern., *Ghau*, Gujaráti; *Galu*, Maráthi; *Godhi*, Kanarese.
3. *Triticum pilosum*, Dalz. and Gibs., "having the calices covered with much soft tomentum" *i.e.*, velvet-chaffed wheat.
   Vern., *Bakshi; káli kusal; kahno.*
4. *Triticum monococcum*, Linn.

The foregoing description is by Professor Gammie.

Habitat. The cultivation of wheat is prehistoric in the old world, and De Candolle believes that the culture of this cereal in the temperate parts of Europe, Asia and Africa is older than the most ancient known languages.

Distribution throughout the World.

This is essentially a crop of the warmer and drier parts of the temperate zone, but its limits of growth are wide, and the varieties in cultivation are so numerous that some are adapted to grow in any country outside Arctic limits. In India approximately thirty million acres are cultivated, of which Bombay claims two millions only. It is grown most extensively in Northern India and always during the cold weather. The young seedlings of the hardier varieties are not killed by frost, but frost or cold causes damage when the crop is approaching maturity. The winter wheats of England and Canada are so hardy that they are fresh and green in spring after severe winter, particularly if during winter the young plants are protected by a light covering of snow. Wheat can be grown successfully with a greater range of temperature than perhaps any other cultivated plant.

Distribution in the Bombay Presidency. The wheat area in the Bombay Presidency varies with the season. It extends in years of favourable late rains. It contracts, if the Septem-

ber-October rainfall is deficient. The great wheat producing districts are Ahmedabad (170,000 acres), Nàsik (320,000 acres), Khàndesh (270,000 acres), Ahmednagar (250,000 acres), Bijàpur (145,000 acres), Dhàrwàr (150,000 acres). But, as already noted, these areas vary considerably with the season.

Suitable soils.

It is extensively grown as a dry crop on deep, black, moisture holding soil. The finest dry crop lands of the Presidency are along the Tàpti in Khàndesh, in the plains of Kopergaon and along the Godavary in Ahmednagar. The Bijàpur, Dhàrwàr and Ahmedabad wheat lands have each black soil, and are naturally fertile if late rains are sufficient.

Wheat, as an irrigated crop, does best on much lighter soil. Medium black soil, so common in the Deccan, is very suitable. Such land is of fair depth, and has a substratum of *murum* 2 or 3 feet below the surface. It occupies the lower levels of the valleys, is irrigable from wells or by *pát* from bunded streams, and, when well manured and carefully cultivated, grows excellent crops of wheat. The irrigated wheat crops of Khàndesh, Nàsik, Nagar, Poona, &c., are all grown in this class of land, whilst those of Ahmedabad, Kaira and Baroda Territory are grown on light alluvium loams. The irrigated crops of Gujaràt are perhaps superior to those of the Deccan, but are far more liable to excessive damage by rust, and are more expensively cultivated, the cost of irrigation being high owing to great depth of wells.

Mixtures.

Dry crop wheat is either grown alone or with subordinate rows of safflower; sometimes linseed occupies the headlands. Wheat and gram mixed are grown in the Panch Mahàls. Irrigated wheat is usually unmixed.

Rotations.

Dry crop wheat is grown continuously in some parts of Ahmednagar, Ahmedabad and Nàsik. In the cotton districts of Khàndesh, Dhàrwàr, Broach, &c., it is rotated with cotton and *jowár*. In the deep black soil which borders the Tàpti in Khàndesh it is rotated with linseed and gram. In the Panch Mahàls on land brought under tillage during recent years it follows a *kharif* crop of maize, the land being double cropped annually. This is an exhaustive system of cropping which can only be practised in virgin land. Irrigated wheat is rotated with ordinary garden crops, but no definite order is followed.

Cultivation of the dry crop.

The preparatory tillage is usually careful. Wheat fields are during the rains usually uncropped; therefore, there is good opportunity for thorough working. Tillage begins usually before the rains by scarifying with a *vakhar* of the Deccan, which corresponds with the *karab* of Guzerat. If the *vakhar* is worked several times in April-May, its

blade scrapes the surface, uproots the stubble of the previous crop, fills the cracks with loose soil, and leaves a friable surface layer which readily soaks up the monsoon rain as it falls during June, July and August. The *vakhar* should be used once or twice a month, but only when the soil is in a suitable condition in respect of moistness. Tillage does harm when soil is wet; but if the surface is dry and crumbly, and if the bullocks at work can walk without leaving deep foot impressions, the soil should be worked as often as possible. The effect of such tillage is to leave the surface soil in a clean, thoroughly friable condition, whilst the substratum, 3 or 4 inches below the surface, retains moisture, and, being more or less consolidated, provides the firm seed bed which wheat likes. Dry crop wheat land is not often manured. When a dressing is given, the manure should be old and thoroughly decayed. It should be applied in August or September, and mixed with the soil by a light ploughing. *San* ploughed in as a green manure provides a cheap and effective manure. If the field is well worked in the hot weather, the *san* can be sown in June-July, and ploughed in in August-September. Subsequently the soil should, as the *san* decays, be worked repeatedly with the *vakhar* in order to keep the surface soil clean and friable and at the same time provide a tolerably firm seed bed. Wheat as a dry crop should, if possible, be sown in October. It will thrive well as an irrigated crop if sown in November or early December. An irrigated crop must necessarily be manured, and a dressing of 12 to 15 loads of old manure per acre is sufficient.

Dry crop wheat is always drilled, a heavy two-coultered drill being used for the purpose. In some districts, as, for instance, in Broach, the rows are very wide apart, rarely less than 18 inches. A heavy drill, with coulters wide apart, deposits the seed deeper than a lighter drill with coulters close together, and sufficiently deep to secure moisture sufficient for regular germination. But the seed is not evenly distributed. The Khándesh method of sowing is probably preferable to that practised elsewhere. A heavy drill with two coulters, about two feet apart, is used. In the forward journey across a field two rows are sown two feet apart. In the back journey two more rows are sown, but one row is intermediate between the two rows previously sown. Thus the crop comes up in rows about a foot apart. But the rows are rather irregular in their distance from each other, because it is difficult to guide the drill accurately. The irregularity referred to is of no great importance, because wheat fields are generally so well prepared that bullock hoeing or hand weeding is rarely necessary. Little or no rain falls usually after the seed is sown, and weeds do not grow with

the same freedom as during the monsoon. The seed rate for a dry crop varies considerably according to district and according to the condition of the soil. The range will ordinarily be from 40 to 55 lbs. per acre. Sometimes the crop is neither wholly dry nor wholly irrigated. If the soil moisture fails and the crop threatens to dry up or ripen prematurely, and if facilities for irrigation exist, the owner gives two or three waterings at intervals of a fortnight. The water is distributed over the field without any system of beds or regular water channels, and the first watering requires much water, the cracks and fissures in the soil gulping the water in an astounding manner.

Wheat is harvested by uprooting by hand, aided by a blunt sickle. The surface soil at harvest time is dry and loose, and the plants are easily uprooted and shaken fairly free of earth particles. The harvested crop is laid neatly into bundles of sheaf size which, after exposure to the sun for a day or two, are tied (thin strips of aloe leaves make good bands), and carted to the threshing floor. Wheat may be threshed out three or four days after reaping or may be stacked and threshed out at leisure. It is usually trampled out under the feet of bullocks, and is easily winnowed by the hot winds which blow in March and April. In Gujarát winnowing is usually done by an artificial air current from a triangular cloth tied at two corners by thin ropes attached to fixed points, and swung or flapped rapidly at the third corner by a man or woman.

The chaff got by the above method of threshing and winnowing provides fairly good fodder. The treading process breaks the awns, and crushes the brittle straw and hard glumes into soft palatable "*bhusa*" which, as food for cattle, is very much improved if mixed with a fair proportion of "*bhusa*" similarly got in threshing leguminous crops.

Cultivation of irrigated wheat.

Irrigated wheat is sometimes broadcasted, sometimes drilled and occasionally sown by hand in the furrows behind the plough, the seed being covered by the soil moved in making the next furrow. If the soil is very friable to a depth of at least 3 inches the latter method of sowing is perhaps best. The seed can with care be sown with great regularity, and, by means of a hand hoe or rake, the field can, after sowing, be laid out into beds for irrigation. A plough should, before the beds are formed, be used to make straight furrows 10 ft. apart. These when deepened by means of a hand hoe serve as water channels for irrigation. The beds should not be more than 10 ft. square. An irrigated crop requires a higher seed rate than a dry crop. 70 or 80 lbs. per acre are ordinarily sown and in the case of spelt wheat in husk 100 lbs. After sowing, the crop requires little attention, besides

regular irrigation. One or two hand weedings may be required, the whole surface soil being stirred with the *khurpa* (weeding hook) at the same time to break up the crust that forms after irrigation. On moderately retentive soil wheat need not be irrigated oftener than once a fortnight. But if the soil is light alluvium as in Northern Gujaràt, the crops should be watered every eight days.

Outturn. The outturn of grain varies much with the season. A well managed irrigated crop produces about 2,000 lbs. grain and over a ton of straw, whilst a good dry crop will not often exceed 1,000 lbs. of grain and about the same weight of straw. 600 to 650 lbs. grain per acre probably represent a full average crop in an ordinary year from deep, black soil, cultivated in the ordinary manner.

Diseases. Rust (*Puccinia graminis*)—*gerva*, Gujaràti; *támbora*, Maráthi—often does considerable damage to the crop. It is most destructive in seasons with cold showers and cloudy weather, especially if such come as the crops approach maturity. Some varieties are less subject than others. *Khapli* or spelt wheat is rustproof. The disease has occupied the attention of agriculturists in all parts of the world. But efforts to completely suppress it have not been successful. In Australia, by a process of selection, varieties, which are nearly rustproof, have been obtained.

Smut is common in Indian wheat, as in all other cereals. But the disease does not appear, except to a trifling extent, if the seed before sowing is steeped for five minutes in a solution of copper sulphate which should not exceed ½ per cent. strength. After steeping, the seed should be dried in the sun.

The following is an estimate of growing dry crop wheat in Khàndesh :—

Cost of Cultivation.

	Per Acre. Rs.	a.	p.
Clearing stubble of previous crop	0	6	0
Harrowing three times in hot weather	0	12	0
Harrowing four times during rains	1	0	0
Manure once in three years, say, 6 loads per annum ...	3	0	0
Ploughing once	1	8	0
Drilling and covering seed	0	9	0
Cost of seed 45 lbs.	2	0	0
Harvesting, carting, threshing and winnowing a crop of 800 lbs. per acre	3	4	0
Total ...	12	7	0

Trade in Indian wheat. A large export trade from the sea ports of Bombay, Karáchi and Calcutta is chiefly fed from the Central and North-West Provinces. Bombay, of course, supplies its small quota. Experts sort Indian wheats as hard and soft whites and hard and soft reds. The hard

wheats are characterised by a flinty, translucent appearance which indicates a high percentage of gluten. The soft wheats are opaque and starchy, and are liked by millers. For native consumption glutenous wheats are more favoured than soft, starchy samples. This is fortunate, as the export trade requires soft wheat by preference. Hard wheats are shipped to the Italian and other sea ports of the Mediterranean, and are utilized in the manufacture of vermicelli, maccaroni, &c. Soft red wheats find a ready market in England. 5 per cent. refraction or impurity is allowed by the trade. Indian samples as sold by the cultivators rarely contain so much impurity, but must necessarily contain earth particles and small pebbles, because the crop is harvested by uprooting and because the means at hand for winnowing and screening are imperfect.

Milling wheat.

In the miller's estimation the valuable qualities of wheat are (1) colour, (2) strength, (3) flavour.

Colour.

Wheat varies in colour from pale yellow to dull red. White bread is most esteemed, and can only be made from white flour. In the old method of grinding wheat between stones, flour of better colour could be got from white wheat than from red, therefore white wheats were valued at considerably higher rates than the red; but, since the roller system of milling has been introduced, white flour can be got equally readily from white and red grain.

The roller system of milling is called the "gradual reduction process." The aim is to remove the bran in scalelike pieces which can readily be separated by sifting and winnowing, and leave the inner farinaceous portion in gritty fragments which can subsequently be rolled or ground into fine flour. The germ of the wheat, which is yellow and oily, must be separated. It is unnecessary to enter into details regarding the gradual reduction process in all its stages. It is sufficient to know that pure white flour may thereby be got from wheat of any colour.

Strength.

This quality depends chiefly upon a large quantity of elastic gluten. Certain varieties of wheat contain a higher percentage of elastic gluten than others. The dough made from the flour of such varieties, when baked, rises into a larger loaf than would be got from the flour of weaker wheat. Strength does not depend upon varieties. The same variety may in one season produce fairly strong wheat in another weak. This is particularly the case in temperate countries. In England the summer is sometimes unusually hot and dry, and in such seasons the grain is much more translucent and glutenous than in average seasons when it is dull, starchy and weak. The character known as hardness is by no means constant. In fact, hard and soft

grains can be got often from the same ear. Indian wheats and wheats grown in the hotter and drier parts of Russia, America, &c., are strong. Countries with damp temperate climates, such as England and the sea board States of America, yield wheats which are weak. Indian wheats in Europe are in demand for mixing with English and other wheat, which are deficient in strength.

Flavour is best when strength is least. English wheats are better flavoured than those of any other country, partly on account of climate, but chiefly on account of the care exercised in the selection of seed. Indian wheats have a peculiar flavour which millers call "beany," *i.e.*, a taste resembling the *dâl* of any pulse. For this reason Indian wheats are mixed with English and those of other countries before being ground into flour. There is art in proper mixing, because colour, strength and flavour are never found in the highest perfection in one variety. These qualities, if present in any variety in proper degree, add to its market value. They can be developed by the effect of climate, soil, cultivation and selection of seed. Climate can hardly be controlled except that irrigation can replace deficient rainfall. Deep, stiff loams and well drained clay soils with sufficient rainfall produce grain of finer quality than lighter soils, but this remark must be modified in respect of irrigated crops. By a process of seed-selection carried on from year to year, the quality can be very much improved. In this process of selection the aim should be to get plump, large grain with a thin clear skin, a heavy weight per bushel, true to type, and with strong bright straw which will stand up well if the crop is heavy or during heavy rain-storms. 13,407

Milling qualities of typical Indian wheats.

The milling qualities of typical Indian wheats were gauged by McDougall Bros., of Mark Lane, London, in 1882, with the following results :—

		Weight per Bushel.
No. 1.	True soft white	64 lbs.
,, 2.	Superior soft red	62¾ ,,
,, 3.	Average hard red	60 ,,
,, 4.	Average hard white	61¼ ,,

		Flour. Per cent.	Middlings. Per cent.	Pollard. Per cent.	Bran. Per cent.
No. 1.	Ground under mill stones ...	77·46	0·82	8·8	12·0
,,	,, rollers ...	74·1	11·00	5·7	4·0
No. 2.	,, mill stones ...	78·0	1·68	9·3	9·4
,,	,, rollers ...	75·4	7·7	13·5	5·5
No. 3.	,, mill stones ...	80·52	0·78	10·0	8·3
,,	,, rollers ...	78·2	10·3	14·3	3·1
No. 4.	,, mill stones ...	79·88	0·78	13·2	8·5
,,	,, rollers ...	74·2	10·8	13·8	3·0

Characteristic Appearances of Bombay Varieties.

The straw in all varieties is comparatively short. In a highly manured irrigated crop it may reach 3½ft. in height, but in ordinary irrigated crops it ranges from 2½ ft. to 3 ft. In a dry crop it is often very short, in which case the yield of grain per acre exceeds, to a considerable extent, the weight of straw. In most varieties a fully grown stalk has four nodes, rarely more or less. The nodes are dark in colour, but vary in shade according to variety. The extent of tillering varies with the variety, with the vigour of growth, and with the seed rate. The plants in a thickly sown crop do not tiller to the same extent as in a crop sown thin. Ordinarily, there are four to seven stems from one root, but in vigorous growing plants the number is much more. The straw varies in colour and brightness according to variety. The withered side leaves are generally a darker shade than the stem proper which may be bright and shining or dull. When very bright and shining, the straw is usually very light in colour, *i.e.*, pale-cream, nearly white. When dull in colour, the straw is darker, generally a dull yellow colour, tinged with brown. In one or two varieties the straw immediately below the ear is bent in a serpentine manner in two or three short curves. The glumes and awns of the ear are not usually the same colour as the straw. They are generally either lighter or darker in colour.

The grain, according to variety, may be classed into hard and soft red, hard and soft yellow, and hard and soft white; but, with one single exception, there is no variety that can be classed as soft wheat proper. There are certain red, yellow and white wheats which are unquestionably hard varieties, the grains being flinty and translucent to a high degree. On the other hand, there are red, yellow and white wheat which have in the same ear some grains hard and flinty, others only moderately translucent and on section showing a starchy appearance to a certain extent. Very few varieties have short, rounded, plump grain. In most cases the grains are long and eliptical, fairly well filled, and heavy in the case of a good variety and a good crop.

The period of growth varies between varieties, and depends also upon the date of sowing, the condition of the soil, regularity in irrigation, or in the case of a dry crop on the character of the season. A crop sown in October or early in the cold weather will take longer to mature, and probably yield better than one sown in December or later. An irrigated crop in rich soil matures slowly and yields very well. A dry crop with scanty late rainfall may be forced to maturity quickly, and the period from seed time to harvest may be only three

months or less; whereas, under more favourable conditions, the period of growth will be from 3½ to 4½ months.

The ears of all Bombay varieties are awned and nearly all erect in a ripe crop. The spikelets are ranged in all cases on either side of the rachis, alternately. They may be attached at short intervals in which case the head is dense, or at longer intervals in which case it is more or less open. The spikelets in the middle of the grain may contain two, three or four grains according to variety. Those at the base or point of the grain generally contain two grains or two fully developed grains, and a third much smaller. Most varieties are "square head" in appearance.

Glumes. In some varieties glumes are hard and shining, in others downy, or, when the down is considerable, "velvet chaffed." Hard shining glumes have often a slight degree of bloom, particularly when the main colour is brown or yellow brown. In one variety (*khapli*) the glumes securely enclose the grain. In others the grain can be separated comparatively easily. The awns on some varieties are long and securely attached to the glumes, in others shorter or less securely attached. The colour of the awns generally corresponds with that of the glumes, but there are exceptions. Thus several varieties with nearly white chaff have dark coloured awns, black or dark brown near the base and gradually shaded off to a pale drab or dirty white towards the point.

RICE, *Oryza sativa*—Linn.

Natural order—*Gramineæ*.

Tribe—*Oryzeæ*.

Grain or Paddy ...	Dàngar ...	... Gujaràti.
	Bhàt ...	... Maràthi.
	Bhatta ...	... Kanarese.
Straw	Paràl ...	... Gujaràti.
	Pendha ...	... Maràthi.
	Bhattad hullu	... Kanarese.

Habitat. Rice is found truly wild in marshy lands in tropical countries. Its chief wild habitat is, however, from Madras and Orissa to Bengal, Chittagong, Aracan, and possibly even to Cochin China.

Rice, *Oryza*—Linn.

Botanical description by Professor Gammie.

Spikelets in pannicles. *Glumes* 4, the *two lowest* minute, *third and fourth* sub-equal, without pales. *Stamens* 6.

Oryza sativa, Linn.

Annual, tufted, grown in water. *Leaves* many, rather rough, sheaths smooth. *Pannicle* elongate, erect at first, drooping as the grain ripens. *Spikelets* loosely arranged; *third glume* with a very long awn.

Season of growth.

Rice is grown at all seasons in different parts of India, provided there is water. The varieties are extremely numerous, and particular varieties are found, not only suitable for different seasons, but also for different soils, different systems of cultivation, and different conditions of climate and rainfall.

Dr. Watt mentions five crops a year as being grown in Bengal.

In Western India rice is chiefly a *kharif* crop, dependent mostly upon natural rainfall. In the Southern Collectorates of the Presidency, especially in Kánara, *rabi* rice which ripens in the hot weather is grown. This is called *vaingan* rice. The district gets the benefit of the North-East monsoon, and gets late rain. *Vaingan* rice is generally assisted by irrigation and usually by channel water drawn from a nullah or from natural springs.

General distribution throughout the world.

Rice is very extensively cultivated in all the warmer parts of the world. It is essentially a crop of damp, semi-tropical or tropical countries. It thrives under great diversity of climate and culture. It grows well in dry climates or at least dry in comparison with Burmah, Bengal and the Konkan Districts of the Bombay Presidency. The finest varieties and the largest yields per acre are produced in districts where there is a moderate degree of sunshine and a damp, warm atmosphere.

India has a very extensive area, probably, on an average, considerably exceeding seventy million acres annually. The Bombay area is less than two million acres. Rice has been grown in India since the very earliest times.

Distribution in the Presidency.

The chief rice areas are below and on the Western Ghats. The crop is especially important in the belt of low land which lies between these hills and the sea from the most southern part of the Presidency, as far North as Bulsár in the Surat Collectorate, also in the cosy below-ghát valleys, and in the artificially terraced rice beds, which are so numerous along the eastern and western slopes of the ghát range. The rainfall throughout these parts is very heavy. In some places on the hills over 200″ are registered from June to October. In the coast belt the rainfall is 100″ more or less in a season. In the upland plains of the Deccan and Southern Maratha Country, which stretch away from the eastern slopes of the ghats, the rainfall rapidly declines, and at no great distance away from the hills rice gives place to millets.

In the northern tálukas of Surat, in Broach, Baroda Territory, the northern collectorates of Gujarát, and in Kathiawár the rainfall is lighter. Therefore, in these districts on the open, fairly level tracts rice beds occupy positions specially favourable for impounding rain-water. They are not only embanked, but also in some cases dug out to improve their capacity for holding water. They have usually the additional advantage of being under a tank or other source of irrigation.

In Gujarát, Surat and Kaira grow each about 100,000 acres annually, Ahmedabad and Panch Maháls each 50,000 to 60,000 acres, and Broach 20,000 acres.

In the Deccan on an average the Násik area is about 60,000 acres, Poona 70,000, Sholápur 20,000, and Sátára 45,000 acres. In the Karnátak, Belgaum and Dhárwár grow, respectively, about 115,000 and 160,000 acres, mostly in their western hilly parts.

In the Konkan, Thána has over 300,000 acres, Kolába about 250,000 acres, Kánara about 200,000 acres, and Ratnágiri 50,000 acres.

Rotations and mixtures.

It may generally be said that rice is grown year after year on the same land without any rotation. This is certainly the case in the Konkan. In years of favourable late rainfall a second crop of *vál* or gram or castors or wheat or of mixed *vál* and castors or mixed gram and castors may be grown. This second crop is, however, more common in the tank irrigated rice beds of Northern Gujarát and elsewhere than in the Konkan rice fields which depend solely on rainfall.

In the rice lands of the southern tálukas of the Surat District, it is common to grow a crop of sugarcane once in four years or at longer intervals, and the same practice prevails in the laterite soils of Belgaum, Dhárwár, and in the above-ghát parts of Kánara. In these Belgaum and Dhárwár terraced rice beds a sprinkling of *jowár* is sown with the rice, and in years of average rainfall both crops seem to thrive. The conditions of rainfall most favourable for rice are entirely unsuitable for *jowár*, and the mixture referred to is a very unusual one. In Broach on deep, black soil and in the tálukas where the average rainfall exceeds 40 inches, rice is sown as a subordinate row crop with cotton. Elsewhere in Gujarát, where the land is not true rice land and the produce is uncertain, *kodra* and rice, with a sprinkling of *tuver*, are a common mixed crop. These fields are without embankments.

Soils.

The best soils for rice are clays or clay loams of fair depth. The substratum should be *murum* or other porous material. This secures fair natural drainage, and the soil is thereby improved for rice. The

plant is naturally acquatic, yet it does not thrive in a soil in which water stagnates. The crop luxuriates in a soil through which water percolates with freedom and over which it flows slowly.

The Konkan rice soils are mostly greyish-black clays or clay loams. Those of Surat and Broach and Kathiáwár are black or brown-clay. The Kaira, Ahmedabad and Panch Maháls rice beds are light coloured or light brown *'besar* (clay loam) soils. Those of the Karnátak are yellow red or reddish-brown laterite clays or clay loams. Any description of soil which is moderately deep (2 to 3 feet), of fine or fairly fine consistence, and moderately pervious to moisture, is suitable for rice. In districts where the rain fails early, as in Gujarát, the important point is that the soil should retain water as long as the rice is likely to need it. Embankments are formed, and the surface of rice beds made level, so that water can be impounded and kept at a height which varies as the crop grows. At no times should more than two-thirds of the plant be immersed.

Terracing, embanking and reclaiming rice land.

In almost all rice fields the original surface required a certain amount of levelling and digging out, and the excavated soil was used in filling hollows or in forming the embankments. On and under the ghâts on the gentle slopes of valleys and on the steeper slopes at the foot of the hills, rice beds have been formed in terraces with great ingenuity and at considerable cost. Where the original surface was uneven, sloping or fairly steep, the rice beds are necessarily smaller in area and more irregular in shape than in the open, more level tracts. In a particular group of terraced rice beds a stream fed by drainage of higher levels is made to distribute its water equally over all, and the surface is so levelled and the embankments so arranged that a slow stream passes over the beds in succession from higher to lower levels. The embankments are made of mud and necessarily range according to situation, from 18″ to 2½′ high, the width being proportionate to their height and the construction being sufficiently strong to stand the pressure of water impounded in them. Such rice beds as receive the inflow of water brought by nullahs from the hills are enriched by the fine silt which is deposited from the muddy water as it flows slowly through.

A considerable extent of rice land in the Konkan has been reclaimed from the sea, principally along the course of tidal creeks. The first operation has been to form an embankment sufficiently high and strong to exclude the water of high tides. The soil from higher levels is carried in to fill up and raise the surface level inclosed by the

embankments. The natural low lying position of these reclaimed rice beds is favourable for impounding rain water. The reclaimed land is, to some extent, salt for a time, and is only suitable for growing inferior varieties of "salt" rice. In time the soil becomes sweetened by cultivation, and then superior varieties can be grown.

Manuring. Many rice fields on and under the ghâts are never manured, only the seed bed on which the seedlings for transplantation are raised. These below-ghât rice beds are "warped" year by year. The mud or silt carried by the numerous nullahs and small streams from higher levels is deposited on these rice beds, and the depth of soil is yearly increased. Moreover, the continuous slow passage of water through and over these soils has a softening effect upon the soil, causing considerable elimination of plant food from dormant ingredients. Nitrogen is the one element which might reasonably be expected to be deficient, but the yield from these unmanured rice beds is not decreasing, and there is no evidence to show that the land is becoming exhausted. Although many rice fields on and under the ghâts are not manured, the seed beds invariably are either by burning *ráb* material thereon or by the direct application of manure. The *ráb* practice has been fully described in a separate chapter (*see* Volume I). It is confined to districts of heavy rainfall.

In those parts where the rainfall is 50" or less, rice seedlings are raised in nurseries which are manured heavily with ordinary manure or by folding sheep and goats. The effect of burning *ráb* material on the seed bed is not so much manurial as physical. A properly prepared rice bed is lightly dug a few inches deep with a light pick, and the loosened surface broken up fine. Over this the *ráb* material is laid and burnt. The ashes are mixed through the fine earth. The heat has killed seeds of weeds. The seed can be sown with the first signs of rain, and if rain holds off, artificial watering can be given to the small patch for a few days. The seedlings come up strong and vigorous, and can be transplanted early into the main field which, as the seedlings were growing, should be got ready by repeated ploughings for transplantation. A crop grown from early transplanted seedlings gets the full benefit of the monsoon rain, and this is extremely important in the case of the finer varieties which ripen late, and require much water late in the season.

The rice beds of Gujarát and those of the flat bottom lands of the Konkan and elsewhere are regularly manured, and the heavier the dressing of manure, the better the crop. Tank mud in Gujarát is

favourite application. Tank mud or ordinary manure is given at the rate of 40 loads or less per acre as can be arranged. The manure should be applied evenly over the surface before the rains set in. In Gujarát the practice of green manuring is common. *San* (*Crotalaria juncia*) is sown thickly with the first fall of rain and after a single ploughing. A turn or two of the harrow covers the seed. The *san* grows to a height of 18 inches, whilst the seedlings are growing in the seed bed. Then it is trampled into the soil, as the field is puddled and made ready for transplantation by repeated ploughings. Castor cake is cheap in Gujarát—about 80 lbs. per rupee—and a topdressing, costing Rs. 5 or less per acre, is given to supplement a light application of ordinary manure. Fish manure, costing about 80 lbs. per rupee, is similarly employed in the southern talukas of Surat and parts of the Konkan. In Kánara and in the forest tracts of Dhárwár green leaves and green twigs of certain forest trees are used as a sort of green manure.

Seed rate and methods of sowing.

Rice is sown (1) broadcast, (2) drilled, (3) broadcasted in a seed bed and thence transplanted. Generally, except in the case of salt rice grown on marshy situations reclaimed from the sea, the first method is only adopted by the worst cultivators. The second plan is very common in the western talukas of Belgaum and Dhárwár and above the ghâts in Kanara, also in unembanked fields in Gujarát. The third method is less risky and more successful than the others, and is particularly suitable for fields which are embanked and where the rainfall is over 80 inches or where deficient, late rainfall is supplemented by irrigation from tank or otherwise. Broadcasted or drilled rice requires a higher seed rate than transplanted rice. The *vaingan* (hot weather) rice of Kánara requires a seed rate of 160 to 200 lbs. per acre. Broadcasted or drilled rice requires 120 lbs. per acre, and the seed rate of the transplanted crop varies per acre from 25 or 30 lbs. to 90 or 100 lbs. The latter is the common seed rate in Surat and Broach. In no other districts of the Presidency is so much seed required. Everywhere the seed bed is thickly broadcasted. A sufficiency of seed is allowed to meet contingencies.

In the Konkan rice is sometimes artificially germinated before it is broadcasted. The object is to gain time by getting seedlings as early as possible. The seed is made damp and germinated in heaps or baskets when there are signs of approaching rain, and is sown broadcast when the first showers have moistened the soil sufficiently. This method is hazardous, except in salt rice lands which are sown when covered with water. It is better to sow in the ordinary way and irrigate by

hand. The seed for "salt" rice is often broadcasted on rice beds over which water stands; the seed sinks into the soft mud. The drilled rice of Dhárwár and Belgaum is sown with a 6-coultered drill. The coulters are about 8″ to 10″ apart.

The Bombay Varieties of Rice.

Their characteristic differences.

The varieties cultivated are very numerous. I have examined and described over sixty varieties. These can clearly be identified as different from each other. They form probably only a small proportion of the varieties grown within the Bombay Presidency, and necessarily are an exceedingly small proportion of the varieties cultivated throughout India. In examining the particular varieties referred to, it was made clear that mixed seed is commonly sown. At the same time it was made equally clear that rice cultivators have a natural knowledge of the various varieties grown in a particular district, and know the conditions of soil, season, water, &c., which are most favourable for the growth of each variety.

Commercially, the paddy might be classed into very fine, fine, coarse and very coarse varieties; but it is very difficult to grade varieties into these classes. It is easy to state definitely that one variety is very fine, and another is very coarse, but there are very numerous gradations in quality between those two extremes.

The chief differences between varieties, which I have noticed, are detailed below.

Period of growth.

There are early, medium and late ripening varieties. The earliest in an ordinary season reaches maturity at the end of September, the latest towards the middle or end of November.

Soils and water-supply.

Some varieties, generally the late varieties, require deep, good, retentive soil, with well embanked rice beds favourably situated to impound rain water or to receive irrigation when the rainfall is deficient. Other earlier ripening varieties will thrive well on thinner, poorer, less retentive soils and with inferior facilities for impounding water or for irrigation. There are numerous gradations between the two extremes. Certain coarse varieties are adapted for cultivation in salt land reclaimed from the sea, and such generally thrive best with much water in the rice beds.

Sowing or planting.

The finest varieties are usually grown from seedlings which have been transplanted from a seed bed into the field proper. Other varieties which are not so fine will thrive well if the seed is drilled, and the coarser varieties are often broadcasted.

The greater number of varieties are grown in the monsoon, and would not thrive if sown or planted at any other season. A few varieties are suitable for cultivation under irrigation during the cold and hot weather. This crop is known as *vaingan* rice. Season of growth.

There are notable differences between varieties in the length, strength, colour, and brightness of the straw ; also in tillering power. Some varieties produce more stems from one root than others. The finer varieties have not necessarily fine straw, nor the coarser varieties coarse straw. The straw of all varieties, whether it is coarse or fine, is very hollow. If the leaves and leaf sheaths are stripped off, the stalks on account of the hollowness referred to can be drawn between the finger and thumb and pressed into ribbon like strips. If the stalks are further examined, they will be found wrinkled longitudinally. The coarser and more hollow the stems are, the greater is the extent of wrinkles. As regards leaves and leaf sheaths, there are characteristic differences between varieties. Sometimes the leaf sheaths are very large, wrapping the stems very loosely ; sometimes they are not so fully developed, and wrap the stems fairly tightly, particularly towards the top. The sheaths, like the hollow stems, are longitudinally wrinkled in a ripe crop. Apparently the hollowness of stem and the development of leaf sheath furnish air chambers which support this semi aquatic plant in deep water. Therefore, it might be expected that such varieties as need much water should have very hollow stems and very large leaf sheaths. This, however, does not always hold good. The straw of all varieties is weak. As a dry crop the straw would not support the head of grain. It would lodge. Tall straw may be 4½ or 5 feet high, short straw about 3 feet, sometimes less. The straw may be bright and light coloured or dark and dull coloured, varying in colour from pale yellow to dull yellow, tinged with brown. The sheaths and leaves are not usually the same colour as the stems. They are darker generally. Straw.

The head of grain may be a large, drooping panicle or an erect small one or take many intermediate forms. Head of grain.

There are very extensive differences between varieties in the size, shape and colour of the paddy. It may generally be stated that the majority of the finer varieties have long thin grains, sharp pointed, and slightly bent, and triangular or somewhat three cornered on cross section. The colour is generally pale yellow or golden yellow with perhaps faint traces of brown, and the husk is not deeply grooved longitudinally ; the husk may or may not be flossy. The rice or husked grain of fine varieties is generally pearly white, very translucent, flinty when broken, long and not thick. The very finest varieties give fragrant or scented rice. Grain (paddy).

The finest varieties weigh from 900 to 1,400 grains of paddy per *tola*, and range chiefly from 1,050 to 1,300.

The coarser varieties can generally be easily identified by the grain. The majority of coarse varieties have large, full bodied paddy, deeply scored on the husk, and these scores appear to a less extent on the rice. The colour may be yellow or yellow with longitudinal scores of reddish brown or reddish brown with longitudinal scores of yellow or nearly entirely reddish brown or purplish black or dirty grey or drab. In coarse varieties there is generally a conspicuous extent of floss on the husk. Often there are awns. The rice or husked paddy may be white, creamy white, pale brown, bright reddish brown or deep reddish brown. Coarse rice is not usually very pearly, and is generally opaque. The rice is always plump and generally not long. It is soft when bitten, not flinty.

The weight of paddy grains per *tola* in coarse varieties may range from 320 to 900, but usually ranges from 500 to 600 per *tola*.

The general descriptions given as applicable to fine varieties and coarse varieties are not applicable in every case. For instance, there is a particular kind of rice grown extensively in the Presidency (of which there are at least three varieties), which are commercially classed as of the finest quality which have some characters common to fine varieties and some common to coarse. I refer to the varieties known as *ambámohor* and *bodka*. The paddy is deeply grooved, short and plump. The *ambámohor* has a colour generally found in coarse varieties, and it is awned. The rice (husked paddy) is white, opaque and soft, but it is fragrant or scented, and commands a high market rate.

Cultivation in the Konkan.

The seed beds should be hand dug and then *rábed*. The *rál* material is burnt in March or April. The ashes should be mixed with the soil by light digging, and the seed sown about the end of May and covered carefully by a long handled rake. Hand digging before the burning of the rab is better than ploughing afterwards. The heat penetrates the loosened soil better. In tracts of heavy rainfall the burning of *rál* materials before the rains is a much better preparation than the direct application of manure. The probable explanation of this is that ordinary manure, if kept excessively wet, undergoes no chemical changes by which useful plant food would be liberated. Therefore, in the Konkan, with its excessive rainfall, manure for a rice seed bed would be of very little use unless applied when very old and thoroughly decayed. Under average conditions, 6 to 8 lbs. of seed should be broadcasted on each *guntha* ($\frac{1}{40}$ acre) of seed bed, and from

4 to 8 *gunthas* of seed bed are required per acre of plantation. 5½ *gunthas* of seed bed per acre of transplantation may be taken as average.

In a well *rábed* seed bed few, if any, weeds appear. The seed bed should, however, be carefully weeded. The seedlings, if they grow unchecked, are ready for transplanting in 25 to 30 days. They should then be 8″ to 10″ high. The cultivation of the general area begins when the soil is well soaked, and should be complete by the time the seedlings are ready. The field is made ready for transplanting by repeated ploughings with a light plough usually drawn by buffaloes. It is puddled into thin mud. The stubble and weeds and remnants of previous vegetation disappear in the mud during the process of tillage. The embankments need repairs annually.

Transplanting.

In removing the seedlings from the nursery, care is taken not to damage the plants or harm the roots. Water is allowed to stand on the seed bed, so that the seedlings are easily uprooted. In this water the roots of the seedlings are washed free of adhering earth. Two handfuls of seedlings are tied into a neat bundle. The bundles are carried to the field, and are distributed near the planters. They float on the water which stands about 6″ deep over the mud as the field is planted.

The seedlings are planted by women by hand, the root ends being simply forced into the soft mud. Two to six seedlings are planted together at intervals of 6″ to 8″. If the seedlings are strong and vigorous, two or three in one place are sufficient. The regularity and deftness with which the work is done is astonishing. For uprooting seedlings, carrying to field and planting, 12 to 15 men and women are required per acre per day. The work is usually done in pouring rain, and men and women are each protected by a simply constructed hood (*virle*), made of light wood and overlapping leaves, bound securely and so shaped that it covers the head and back. Immediately after planting, the seedlings stand in water with their tops just above it. In a week the seedlings will have rooted, the water is partially withdrawn, and dead plants are removed and replaced. Subsequently, the crop should stand in water with one-third of the plant always above it. The water should be drained off occasionally for weeding; but when there is sufficiency of water, little weeding is required. The water is finally drawn off (if the field has not already dried up) about ten days before the crop is ripe.

Harvesting and threshing.

The field should be comparatively dry when the crop is harvested. Early varieties are ready in October, the late varieties in November. Reaping is done with a sickle and close to the ground. The cut crop is laid in open bundles of sheaf size, and these should be exposed to the sun for a few days. If there is risk of rain, the crop is bundled, stacked and protected by thatch near the threshing floor as expeditiously as possible. The grain may be threshed by treading out in the

ordinary way, but the common plan is to thresh the grain when the sun has dried the cut crop sufficiently. The grain is nearly all easily separated by beating small untied bundles on a board. A large cloth is spread anywhere in the field or on the threshing floor. On this cloth a board about 2′ × 3′ is placed. The edge of the board on one side is supported on a thick, short log. The man who threshes the crop sits or stands or kneels on this side. He beats a small bundle at a time. A few vigorous strokes separates the grain. The straw is tied up as it is threshed into neat bundles and stacked. Paddy threshed in this way should not be stored in bulk until it is well sun dried.

Yield per acre. The yield in different districts and from different varieties varies considerably. A full yield of paddy under the most favourable circumstances will be less than 4,000 lbs. per acre. A full average under favourable conditions of rainfall, &c., from a transplanted crop would be 2,800 to 3,200 lbs. per acre of grain. Broadcasted and drilled rice yield much less. A full crop would be 1,800 lbs. paddy or less.

Rice straw varies in outturn with the variety. Coarse varieties have long, rank, inferior straw. Two tons of straw per acre are often obtained. The straw is of low, nutritive value. A good deal of grass is usually obtainable in rice tracts. The straw, when threshed on a board as described, makes excellent thatch.

The following is an estimate of the cost of cultivating an acre of transplanted rice where *rábing* the seed bed with cowdung, &c., is practised:—

Cost of Cultivation in the Konkan.

	Per *Guntha*. Rs. a. p.	Per Acre. Rs. a. p.
Cost of preparing seed bed, arranging and burning *rãb*, hand digging, levelling, sowing seed and covering	5 0 0	
Seed 6 lbs. (32 lbs. per rupee)	0 3 0	
Total ...	5 3 0	
5½ *Gunthas* seed bed for one acre of transplantation		37 11 0
Repairing embankments		0 8 0
Ploughing and puddling field		4 0 0
Cost of lifting seedlings, carrying to field and transplanting		2 8 0
Hand weeding and replacing dead seedlings		1 4 0
Reaping, bundling, carrying, and stacking..		3 8 0
Threshing and winnowing at 2 annas per 100 lbs. paddy		3 8 0
Total cost of Cultivation per acre ...		52 15 0
Estimated outturn grain 2,700 lbs. per acre at 40 lbs. per rupee		67 8 0
Straw per acre		5 0 0
Total Value of Outturn per acre ...		72 8 0

Cultivation in the Surat District.

The seed bed is prepared either in the field or in a plot of land commanded by irrigation from a well. The soil of the seed bed should be ploughed immediately, if possible, after the harvest of the previous year, and worked smooth by repeated harrowings, or hand dug in May, and the soil pulverized to a fine tilth. One full cart load of old cowdung manure or goat manure should be given per *guntha* ($\frac{1}{40}$th part of an acre), and mixed thoroughly with the soil. In the southern part of the district *rál* material is burnt on the seed beds, but the rainfall there is heavy, and this part of the Surat Collectorate really geographically belongs to the Konkan. The rainfall is much less where the seed beds are manured. At the end of May or early in June the seed is broadcasted in the seed bed. About six *gunthas* of seed bed are required for an acre of transplantation, and 90 to 100 lbs. of seed are broadcasted in the 6 *guntha* seed bed. The seed should be carefully covered, so that it is about $1\frac{1}{2}''$ to $2''$ below the surface. When the seedlings come up, all weeds should be removed. These may be numerous if farm yard manure is used. The seedlings are ready for transplanting three to four weeks after sowing.

The main field (*kiári*) is manured in May. There is a traditional saying in the district that *kiáris* should get one cart load of manure per *vasa*—3 *vasas* = 4 *gunthas*. So the traditional rate of manuring comes to 30 cart loads per acre. Very often the supply is not equal to this demand, but the very best cultivators give as much, or they top dress the crop with castor cake to make up for a deficient supply of ordinary manure. The *kiári* (embanked field) is ploughed twice early in June, when it has been well soaked by the first monsoon rain, and afterwards, when the seedlings are nearly ready for transplantation it is puddled by further ploughing and trampling of the work-cattle. At this time a good deal (one foot or less) of water is impounded in the *kiáris*. The operation of puddling is called *ghaval* or *kádav pádvo*. After ploughing, a plank leveller (*pánya*) is used to level and smooth the surface. The field is now ready for transplantation, and the subsequent operations of transplanting, weeding and harvesting are precisely the same as already described for the Konkan. In Surat, however, particularly in the northern *tálukas*, rice needs several waterings late in the season, as elsewhere in Northern Gujarát, from a tank or other source of irrigation. Late in the season, particularly in a year of deficient or even slightly deficient rainfall, the water has to be lifted to the level of the discharge outlet of the tank, from which it flows to each rice bed by gravitation. The lifting may only be a few feet, and it is done very expeditiously and cheaply by means either of

a scoop lift swung by two men or by means of a counterpoise water-lift which is described in the chapter on irrigation. The grain is threshed on a board, as already described. Subsequently, the straw is often trampled by bullocks. Thus the fodder is improved, and a little additional grain obtained. Further details of cultivation are sufficiently indicated by the tabulated statement below which gives an estimate of the cost of cultivating a rice crop on *kiâri* land in the Surat District :—

Cost of Cultivation.

	Per Acre. Rs.	a.	p.	
Preparing seed bed; tillage on 6 *gunthas* per acre of plantation ...	2	0	0	
Manure 6 loads to seed bed and 20 loads to rest of acre area at As. 8 per cart-load	13	0	0	✓
Cost of seed 80 lbs :	2	8	0	✓
Ploughing and puddling *kiâri* and levelling	4	12	0	
Transplanting	2	8	0	
Weeding seed bed and *kiâri*	1	8	0	
Top dressing with castor cake 200 lbs. per acre and application...	3	0	0	✓
Cutting, carrying, threshing paddy and winnowing in field for crop of 3,000 lbs. per acre	4	8	0	
Tying and stacking bundles of straw (*pârâl*)	0	12	0	
Cost of raising water (3 waterings)	4	0	0	✓
	38	8	0	
Add Government Assessment ...	15	0	0	
Total Cost of Cultivation ...	53	8	0	
Probable outturn—				
3,000 lbs. of rice at 40 lbs. per rupee	75	0	0	
Straw per acre	5	0	0	
Gross Value of Outturn ...	80	0	0	

BARLEY, *Hordeum*—Linn.

Stems annual, tufted, smooth. *Leaves* light green, *sheaths* smooth. *Spikelets* one flowered, in pairs or threes in notches or joints of a simple, cylindric spike, with which they are parallel, oblong, compressed ; *outer glumes* small, bristlelike ; *flowering glumes* firm, *awns* long, stiff, with forward prickles. *Grain* grooved on the inner face, tip usually hairy, free or adherent to the pale.

1. *Hordeum vulgare*, Linn. Variety *hexastichon*, Aitchs. *Spikelets*, 6-ranked.

Vern., *Sátu, jav.*

2. *Hordeum vulgare*, Linn. Variety *distichon*, Linn. *Spikelets*, 2-ranked.

Vern., *Jau* (Sind).

3. *Hordeum vulgare,* Linn. Variety *nudum,* Ard. *Spikelets,* 2-ranked; *grain* free.

Vern., *Ua; Ujau; Naked or loose-grained barley.*

The foregoing botanical description is by Professor Gammie.

This cereal belongs to the natural order *Gramineæ*. Dr. Watt says :—"There are many strongly marked forms which, however, are generally "regarded by botanists as referable to one species." The species he refers to is *Hordeum vulgare. Hordeum vulgare* var. *Hexastichon* is six-rowed barley. This variety was the most common in ancient times, and is that which is most commonly cultivated in India.

The finest two-rowed malting barleys of Europe and America belong to *Hordeum vulgare* var. *Distichon.*

Four-rowed barley, known as bere or bigg in Scotland, and which is extensively grown in all cold countries, does not appear to be known in India.

Habitat.

Hordeum vulgare has been found wild in Western Asia, and is among the most ancient of cultivated plants.

Distribution in the Bombay Presidency.

Barley is not extensively grown in Bombay. The area is usually less than 40,000 acres. Ahmedabad grows half the total, Kaira 4,000 to 5,000 acres, Panch Mahâls 2,000, Satara 4,000 to 5,000, Sholápur 3,000, Poona 1,000, and Ahmednagar 400 acres.

General characters of the plant.

The straw of all varieties is short—rarely exceeding 2½ feet in length—and is a dry, brittle, rather unnutritious fodder. One reason for this is that the crop is always harvested when dead ripe. A single seed produces many shoots. In fact, the tillering power of the plant on rich soil is remarkable. Barley is nearly related to wheat. Its range of cultivation throughout the globe is more extended than any other cereal. It is found thriving in all latitudes from the tropical to the borders of the arctic zones and also at very high altitudes. This adaptability is not only due to its power to withstand heat and cold, but also to the fact that it grows rapidly, and thus matures in the short warm summer of northern latitudes or the equally short cold season of tropical and sub-tropical countries. The pales adhere to the grain in most varieties like spelt wheat, but there are two huskless varieties grown experimentally in the Presidency—the one has chocolate coloured grain and the other grain of a pale golden colour.

In most varieties the ears carry long, strong awns like bearded wheat. A few varieties are awnless.

Rotations and mixtures.

In the Presidency barley is grown as a *rabi* irrigated crop, and, like irrigated wheat, is often a second crop in garden land, and takes its place in rotation among the numerous garden crops grown.

Barley is generally grown alone. Occasionally there is a sprinkling of rape or mustard. In parts of Gujarát wheat and barley are grown mixed (*jav kadu*).

Soils and climate.

Barley is essentially a light land crop. The sandy loams of Kaira and Ahmedabad are particularly suitable, but the climate does not suit the crop so well as that of the North-West Provinces. The high day temperature on the sandy soils of Gujarát is too forcing. The crop ripens too quickly, and the grain is usually thin and light. In European countries, where the finest samples of malting barley are grown, the character of the season determines whether it does best on medium light land or on land of a heavier description. In a very dry season, light soil will only produce a crop of thin light grain, whereas, under similar conditions of season, heavy moisture holding clay may yield grain of the finest possible quality. It is very likely that Bombay samples could be very much improved in quality, if due regard be paid to selection of seed and thorough cultivation.

Cultivation—Sandy Soil—Ahmedabad District.

The land is well prepared by repeated ploughings, and at seed time is usually in the finest possible state of tilth. Barley more than any other cereal requires to be sown in thoroughly cultivated friable soil. It does not require such a firm seed bed as wheat does. Therefore, in the Ahmedabad District the common method of sowing is to broadcast the seed in the furrow behind the plough. The seed is thus sown in every furrow, the furrows being opened by the light plough and not more than 9″ apart. The soil moved in opening a furrow covers the seed sown in the previous furrow. The plough should not work more than 3″ deep, otherwise the seed will be too deeply buried. The method of sowing is only successful when previous tillage has produced a fine state of tilth to a depth of 4″ or 5″. As soon as the seed is sown, the surface is levelled and beds for irrigation formed. Barley does best on land in good "condition" from residues of manure applied to previous crops. If the land is not in good condition, a dressing of 10 to 15 loads per acre of thoroughly decayed manure should be given. The manure should be evenly spread over the surface of the field before the first ploughing. Manure applied directly to the crop usually produces a luxurious growth of weak straw which very likely will lodge. The grain is thus damaged in colour and otherwise.

Barley is sown usually in November. If it is not a second crop, it should be sown a month earlier. The seed rate is 80 to 100 lbs. per

acre. If weeds appear, hand weeding is necessary. The preparatory tillage is usually so careful that very little hand weeding is required. The stirring of the surface soil with the weeding hook (*khurpa*) is, however, beneficial. An irrigated crop requires on a loamy soil water every week. A longer interval of ten days or so may be allowed on heavier land. The crop matures in about four months. 1,500 to 1,800 lbs. grain per acre, and about a ton of straw may be considered a full average yield.

Diseases.

Barley in Gujarát is practically exempt from disease, and probably on this account is grown in preference to wheat, the latter crop being often seriously damaged by rust.

Harvesting, &c.

The crop is harvested, threshed and prepared for market in the same manner as already described for wheat.

Economic uses of the grain.

Barley in the Bombay Presidency is only grown as a bread corn or as horse and cattle food. The gluten which the grain contains is not tough and elastic like that of wheat. Consequently, the bread does not rise well in baking. The grain of ordinary barley is often pounded like rice, to separate the husk. The clean grain, except that is more broken, resembles the pot or pearl barley which is used in European households to a considerable extent. Bombay barley is extensively used as a horse food, and for this purpose is usually parched before it is fed.

Cost of Cultivation in Gujarát.

	Per Acre. Rs.	a.	p.
15 Loads per acre manure	7	8	0
Ploughing five times with *hal*	3	12	0
Ploughing and sowing seed	1	0	0
Seed 80 lbs.	2	8	0
Levelling and making beds for irrigation	1	0	0
Weeding by hand	0	12	0
Irrigation—2 men, 1 pair of bullocks, 4 months ...	22	8	0
Harvesting, carting, threshing and winnowing a crop of 1,600 lbs.	5	8	0
	44	8	0
Government Assessment	7	0	0
Total Cost of Cultivation ...	51	8	0
Outturn—			
Grain 1,600 lbs.	50	0	0
Straw 1 ton per acre	6	0	0
	56	0	0

The Value of Barley for Malting and Brewing.

Barley derives its chief commercial value on account of its suitability for malting and brewing purposes. Other grains are used, but not so

successfully. The finest kinds of pale ale can only be brewed from the finest description of malt, and that in its turn can only be obtained from the finest samples of barley.

The qualities which give value to the sample of barley for malting purposes are—

(1) Plumpness of grain and absence of light grain. Thorough winnowing and screening will improve any sample. Fine samples will weigh 57 or 58 lbs. per bushel.

(2) The grain should be bright, golden-yellow in colour, and the pales fine and thin.

(3) Mellowness of grain. This is a trade term which is difficult to describe. It is used in contradistinction to steeliness which is an undesirable quality. All Indian samples are steely.

(4) Absence of damaged grains, *i.e.*, all grains which have lost vitality (*a*) by being broken or bruised in threshing, (*b*) by having germinated owing to exposure to wet, (*c*) by being heated in a stack. Damaged grain will not sprout during the malting process, but will rot and mould and lower the quality of the malt produced.

It is not at all likely that good samples for malting purposes can be produced in the Bombay Presidency. The Deccan Brewers import from the North-West Provinces. The difference in value in England between a sample of high class malting barley and a sample only suitable for grinding or distilling purposes is about Rs. 10 per quarter of 448 lbs. (8 bushels). The English farmer aims at the production of the finest samples—

(*a*) By sowing seed which is plump, thin-skinned, of good colour, and true to variety.

(*b*) He grows his crop on suitable land and under favourable conditions of cultivation.

(*c*) The crop is reaped when fully ripe, and in fair weather is left in open bundles so as to derive for at least three nights the mellowing influence of dew. It is then bound into sheaves and stacked.

(*d*) The crop is stacked when dry. A slight degree of fermentation is beneficial. The slightest risk of heating is, however, avoided. Barley keeps free from any taint much better in stack than it does in bulk, therefore it should be disposed of as soon as threshed.

(*e*) Threshing, screening and winnowing are done carefully and thoroughly.

The Malting Process in England.

If necessary, the grain is thoroughly screened and winnowed before it is placed in the steeping vats or cisterns. It there remains fifty to sixty hours. It absorbs in this time a large quantity of water, and becomes swollen and soft. In this condition it is easily damaged, if not carefully handled. Therefore, the cisterns occupy the upper floors, and are self-discharging, the steeped grain being let down through "shoots" on to the germinating or growing floors. The depth of grain on the floor is regulated by the temperature of the season. The object is to generate sufficient warmth to stimulate the grain to germinate. It is important that growth should commence in the whole mass about the same time. It ought to begin in twelve hours, and be complete in ten or twelve days. It will be completed in a shorter time in India. During the process of growth a remarkable principle, known as diastase, developes, which has the power of converting the starch of the barley into dextrine and sugar. Growth is allowed to proceed sufficiently far to accomplish the change. Growth is then arrested by kiln drying the malt. The whole should be equally heated and equally dried. This is accomplished by a current of dry air heated to any desired temperature. The air supplied through pipes in a furnace is drawn in a continuous current through the perforated floor of the malt kiln, and is made to escape carrying the moisture of the malt with it through an exhaust-fan placed in the neck of a steam outlet in the roof.

The malt when dried is screened to remove the rootlets. These are known as malt dust or malt coombs, and form a valuable cattle food.

Beer is made by infusing the malt with water after it is crushed. Wort and brewers grains are the products. The wort is fermented into beer, hops being first added to give bitterness and keeping qualities. The brewers grains in a fresh state are used chiefly as food for milk cattle, and are dried or dessicated, and keep good for any length of time.

OATS—*Avena*—Linn.

Natural order—*Gramineæ*.

Annual. *Stems* 2 to 3½ feet high, many from one root. *Inflorescence* loosely paniculate; *spikelets* smooth, large, pendulous, each with two or more perfect flowers. Flowering glumes awned on the back; grain furrowed in front, adhering to pale.

OATS—*Avena sativa*—Linn.

Vern., *Jai* or a corruption of the English word.

Habitat.

Watt says, oats are "of recent introduction into Indian agriculture." The crop was first grown in Northern India under English

auspices round cantonments and stud depôts for the supply of horses. The oat is cultivated in temperate regions throughout the globe, even so far North as the Arctic zone. Wild oats are persistent weeds in many of the cultivated fields in England.

In India the finest quality of grain is produced on the lower slopes of the Himalayas. The crop is grown to a considerable extent in the Delhi, Hissar, and Meerut Districts. In Bombay the crop is of minor importance. The area figures are not separately returned. Oats are sparingly grown in Poona, Ahmednagar, Sátára, and Ahmedabad, and also to a less extent in other districts.

Distribution in the Bombay Presidency.

Varieties and general character of the plant.

There are many varieties in cultivation. Those grown in India have been introduced from Europe. Except in the colder parts of India, the grain rapidly deteriorates. The best European varieties have clear, bright, strong straw which is not much inclined to "lodge" during wet weather. The grain should be short and plump, with a small percentage of thin, bright husk, and weigh from 44 to 48 lbs. per bushel. The colour of the grain varies—pale creamy-white, pale yellow, tawny yellow and brownish-black being the most common colours. Tartarian oats are either black or white. The pannicle in this variety is on one side of the flower stalk, and nods to one side as the grain ripens. A particular variety is known in Europe as winter oats. This kind is sown like winter wheat in Europe in October-November. It is not damaged by frost, particularly if snow covers the young plants. All acclimatized varieties grown in the plains in India produce long, thin grain with much husk, and the weight per bushel does not exceed 35 to 37 lbs. usually. The straw, if cut before the crop is fully ripe, provides excellent fodder. The crop is grown at remount and horse-rearing depôts in India, not so much for the grain as the fodder. It is cut green when the grain begins to fill or is nearly filled, and the produce is known as oat hay or "oats in straw." Such fodder is usually chaffed before it is fed to horse stock. This *bhusa* or chaff of "oats in straw" is the fodder which Australian importers use for their horses on the voyage from Australia to India.

Season, soils, mixture.

This cereal is only grown in the *rabi* season, and in Bombay always under irrigation. Oats grow best on well drained, friable soils of fair depth. Very light sand and dense clay are not suitable. The crop is generally grown alone in Bombay, except in North Gujarát where rape is sown as a subordinate mixture.

Cultivation.

Oats are grown on the same kinds of soil and under the same conditions as irrigated wheat or barley. The preparatory tillage and the general cultivation for these crops have already been described. 100 lbs. of seed per acre is required. The seed should be broadcasted like barley.

The crop comes to maturity in 3½ to 4 months. It should be harvested before it is dead ripe. The straw when reaped should have a distinct tinge of green. If left until dead ripe, the grain shakes or sheds out, particularly in windy weather. A good deal then falls to the ground and is lost. Green straw is, of course, better fodder than over ripe straw. The crop is harvested with a sickle, like wheat. It should be in the sun two or three days in untied bundles. The grain can be threshed out like rice on a board, and the bundles of straw afterwards tied and stacked. It is, perhaps, best to trample out the grain under the feet of bullocks. Excellent *bhusa* fodder is thus obtained. A fair outturn from an irrigated crop on good soil is 1,800 to 2,200 lbs. grain and 25 cwts. straw per acre. The chief uses of oats in Europe is to provide oatmeal for human consumption and the grain as food for horses. Indian oats are used almost entirely as food for horses, and should for this purpose be invariably crushed.

Harvesting, threshing, outturn.

Economic uses.

MAIZE, INDIAN CORN—*Zea*—Linn.

Natural order—*Gramineæ*.

Annual, very tall. *Stems* thick, solid, robust, rooting at the lower joints. *Leaves* large, broad, spreading and drooping, arranged alternately along the stems. *Male inflorescence* arranged in a loose panicle, terminating the plant; *female inflorescence* placed close to the stem, in the axils of one or more leaves, enveloped in sheathing bracts which are at first green and become grey-brown when dry; *styles* hanging from the tips of the inflorescence in a long, purple or white tassel; *grains* large, white, yellow, red, brown or black, densely and regularly embedded in a thick, spongy axis.

1. *Zea Mays*, Linn.

Vern., *Maka*, Maráthi; *Makai*, Gujaráti; *Goinjol*, *Mekkejol*, Kanarese; *Bhúta*, Hindustani.

The foregoing botanical description is by Professor Gammie.

Maize is one of the larger and more important cereals of the globe. Excepting rice, it is more widely cultivated than any other tropical cereal. This plant furnishes the food grain of the great portion of the American Continent. It is there known as "corn," and in the English markets is spoken of as "Indian corn," because the first European settlers in America found it the bread corn of the "Red Men of the West." The origin of the plant is uncertain. It is supposed to be indigenous to South America, whence it was imported into Europe. Now it is extensively cultivated in Southern Europe, in Africa, in Australia and in the cooler portions of India. In America the varieties in cultivation are many, and it would be well for Indian cultivators if

General distribution throughout the world.

they exercised the same care in the selection of seed and the improvement of varieties as is practised in America.

General character of the plant.

The plant does not tiller. The stalks in India vary from 4 to 10 feet in height. In Kentucky and some of the Southern States of America it is common to find the crop standing 15 feet high. The grain is carried in an axillary spike (cob). The number of cobs on each stalk, as well as the size of the cobs, will be regulated by thin or thick sowing. Thin seeding on rich deep land will give strong, vigorous plants, carrying large well filled cobs, from which a greater outturn of grain will be got than from a crop sown at a higher seed rate.

Distribution in the Bombay Presidency.

Maize in the Presidency occupies about 140,000 to 160,000 acres annually. The Panch Mahâls claim two-third of the whole. Elsewhere the crop is of minor importance. It is, however, sparingly cultivated in Sholápur, Ahmednagar and Sátára as a grain crop and elsewhere as a fodder crop.

Soil and climate suitable.

The crop requires a hot climate, and is peculiarly susceptible of injury by frost or even cold. It likes a rich, deep, moist soil, well stocked with manure. The plant grows vigorously and quickly, and consequently must be liberally fed. Moreover, it requires a liberal, well distributed rainfall or irrigation when rain fails.

Cultivation in the Panch Mahâls.

In the Panch Mahâls it is grown either as a rain or late irrigated crop. The *kharif* crop is most extensively cultivated, and is usually followed by a *rabi* crop of wheat or gram. Maize with a sufficient rainfall does best on the rich brown soils of Panch Mahâls, which have been brought under cultivation within recent years, and are more or less virgin. Rice land, retentive of moisture either by position or by depth and density, also suits the crop. It is usually sown alone. Its quick habit of growth does not make it a good companion for subordinate mixtures. Occasionally, as in sugarcane, members of the gourd family are grown with it. The practice of taking wheat after maize does not show much appreciation of the value of rotation. Gram after maize is of course better, and with an occasional application of manure this combination could be maintained through any number of successive years. Maize requires a soil deeply and carefully tilled. Consequently, in the brown soil of Panch Mahâls four to six ploughings are given with the light, indigenous plough. This is about equivalent to two good ploughings with a Deccan or Khándesh plough.

The land is as liberally manured (usually in May) as the circumstances of the cultivator will admit. Once in three years is about the

average. The seed rate varies, as also does the method of sowing. 8 to 10 lbs. per acre would be sufficient if the seed were sound and properly distributed. The ordinary plan of sowing is with a two-rowed drill in rows about 20 inches apart. The seeds are large. Only an expert Kanbi can feed the seed with regularity and precision through the seed tubes. Consequently, a plan of dropping the seed by hand into every second furrow behind the plough is often adopted. The seed should be sown as early in June as the land can be properly prepared. The crop tests of the Presidency show that 10 to 15 lbs. per acre of seed is the ordinary rate. The plant during the first month grows slowly as compared with its after progress, and this is one reason why it needs careful weeding while young. The crop should be once hand weeded and two or three times intercultured with a bullock hoe. The crop ripens in three or four months. It is difficult to get the exact outturn of grain in India, because a universal practice prevails of removing and selling unripe ears. Near large towns the whole produce may be disposed of in this manner, in which case the fodder being green is much more valuable. I am inclined to think that the mature fodder of the Panch Mahâls crop is more valuable than the cultivators believe. It is either used for thatching or burnt in the field, and is seldom fed to stock.

Harvesting, threshing, outturn.

The crop is harvested when dead ripe. The cobs are cut off the standing stalks, and, when sufficiently dry, are beaten with sticks to separate the grain. It is difficult to separate the grain from the cob unless the crop is dead ripe, and this is probably one reason why it is left to stand so long. Americans overcome this difficulty by using a husking machine. In the Panch Mahâls an average crop may be estimated at 1,200 to 1,500 lbs. This is poor when compared with the 40 to 60 bushels (2,400 to 3,600 lbs.) per acre of Kentucky.

Cultivation in the Deccan.

In the Deccan the crop is often grown for its fodder. We often find a sprinkling in sugarcane fields, which is cut long before the principal crops shade the ground. When sown alone for fodder, the four-coultered drill is used, and the rows are about 13 inches apart. 20 lbs. seed per acre may be drilled. The crop is cut as the plumes or male flowers make their appearance. As a fodder crop it quickly shades the ground, and therefore one hoeing is all that is necessary. The green fodder is excellent, being very sugary. It may be either fed green or dried and stacked. A heavy crop will yield over 20,000 lbs of green fodder per acre.

Injuries to the crop.

Maize is peculiarly exempt from all diseases, but is often much damaged by pigs, monkeys, jackals, rats and parrots; and cobs being easily removed, night pilfering is common. The crop, therefore, requires careful watching both day and night.

Cost of Cultivation.

	Per Acre. Rs.	a.	p.
Ploughing five times	4	0	0
Proportional cost of manure applied once in three years ...	2	8	0
Harrowing twice before sowing	0	8	0
Seed	0	4	0
Drilling and covering seed	0	4	0
Hand weeding (once)	1	0	0
Bullock hoeing (three times)	1	2	0
Watching	1	8	0
Harvesting, threshing and cleaning	2	4	0
	Rs. 13	6	0

Cultivation in America.

In America the cultivation differs materially from that practised in India. In the former country it is planted in "hills," with as much exactness as tobacco is in the Kaira district. The distance between hills is 3 to 4 feet, with three to five plants on each. This exactness of planting facilitates interculture with horse hoe both lengthwise and crosswise of the field, as well as diagonally. The benefit is obvious. Formerly seed was dibbled in by hand; now a drill is used for the purpose. By a simple contrivance the seed is made to drop from the seed box with such regularity that the distance between hills is accurately the same. The cultivation of maize as a fodder crop in America is much the same as that of a grain crop in India. The seed is deposited in rows, just as it is in the Panch Mahâls, and with a similar distance between plants. In the Western hemisphere, the fodder of a mature crop is considered of much more nutritive value than it is in India. But there the leaves remain green when the cobs and lower ends of the stalks are dead ripe.

Varieties.

In America the varieties in cultivation are many. The grain, according to variety, varies in colour from a creamy white through all the shades of yellow and red to a dark chocolate. Some varieties have striated grain. The lighter coloured grains command in the English and American markets a higher price. Apart from colour, the grain of different varieties have other distinctive characters. The grain may be flat and long or short and rounded. There are sorts with small and large seed. The weight per bushel should exceed 60 lbs. One variety

is extensively cultivated in gardens; because it furnishes cobs which, when the grain is partially filled, are much esteemed as a tender, delicate vegetable. They are superior to the coarse cobs offered in the Indian bazars, but are cooked and eaten in the same way. The pop corn of America is a distinct variety. The cob is small, and is densely packed with small, round, yellow, waxy looking seeds. These, if parched or roasted on a "popper," suddenly explode with considerable noise (hence the name pop corn), and, in doing so, the whole structure of the grain is turned outside in. The outer integuments are found inside, the flour outside.

"Popped" corn, cooked and prepared in a variety of ways, is considered a great delicacy. Although maize flour does not bake so well as wheat, the Americans have a greater appreciation of its value in bread making than any other nation. Hominy, maizina, cornflour are all preparations of maize used in European households. The starch of maize is very easily digestible, and preparations made from maize flour are used largely as food for children and invalids. Economic uses of maize.

There is a practice common in America of saving part of the fodder before the crop matures, which perhaps might be advantageously adopted in India. The green side leaves are stripped off, dried, and bundled at the time when the cobs begin to fill. It is claimed that the outturn of grain is not materially lessened, and a considerable supply of excellent fodder is obtained. This method could not well be adopted in India unless the method of cultivation is changed. The rows are grown near together, and the plants stand so close in the rows that a field is more or less impenetrable, and the leaves when cut from the plants could only with difficulty be removed to the headlands. They might be fed green or converted into silage, but during the monsoon it would be long odds that the fodder would be spoiled by rain long before it could be dried sufficiently for storage. Maize fodder.

In Austria the straw of maize is of commercial value for paper making, for which purpose it is better adapted than most other grasses. It gives a very fine quality of paper, next in quality to that made from rags. In Austrian mills 300 to 350 lbs. dead leaves of maize give 100 lbs. paper, or as much as would be got from 160 lbs. rags.

ELEUSINE—Gærtn.

Annual, smooth. *Stems* tufted, stout, erect, compressed, 2 to 4 feet high. *Leaves* two-ranked, broad, mouth of sheath bearded. *Inflorescence* a cluster of 4 to 6 often strongly incurved spikes. *Spikelets* in two rows, 3 to 6 flowered, closely arranged on the upper side of the axis. *Grain* small, brown, enclosed in a membrane.

ELEUSINE INDICA—Gærtn, cultivated form
E. CORACANA—Gærtn.

Vern., *Bávto* or *Nágli* (Gujaráti); *Nágli* or *Náchni* (Maráthi); *Rági* (Kánarese).

The foregoing botanical description is by Professor Gammie.

Habitat. *Nágli* is believed to be a native of India. At least five grasses of the same genus are known throughout the country, and some yield seed which in famine times is gathered as a food grain. The cultivated plant is widely grown in India.

Varieties. Many varieties of *nágli* exist. They are comprehensively grouped in the Konkan and ghát districts of the Presidency as early (*halvi*) and late (*garvi*), the former ripening in late September or early October, the latter in late October or early November. The seed is small, round, reddish brown or lighter coloured, enclosed in a light drab membrane.

Distribution in the Presidency. This grain occupies the fifth place among the Bombay cereals. In the Kaira and Ahmedabad districts of Gujarát and in adjoining Baroda Territory heavy crops are produced on highly assessed, alluvial soil. Elsewhere in the Presidency the cultivation is chiefly confined to the poorer, upland lands of the ghâts. Gujarát grows nearly 100,000 acres. In the Deccan, Násik grows 160,000 acres, Poona and Sátára about 60,000 each. In the Karnátak, Belgaum and Dhárwár have about 50,000 acres each, chiefly in the hilly parts of the western *tálukas*. In the Konkan, Thána grows 70,000 acres, Kolába 60,000, Ratnágiri 40,000, whilst Kánara has less than 10,000 acres.

Season. Soil *Nágli* is entirely a rain crop in Bombay, and is generally grown in districts of heavy rainfall on land which is too light for rice or too steep to be converted into terraced rice fields. In the fertile, alluvial soil of Kaira and other parts of Gujarát it is grown on *besar* (clay loam) soil. It thrives well on such land with a well distributed rainfall of 30 to 35 inches, and even a heavier rainfall suits the crop admirably.

Mixtures and rotations. In Gujarát, *nágli* is sometimes a drilled crop with *kodra*, *tuver* and sesamum, but is generally grown unmixed and from transplanted seedlings. It rarely occupies the same field oftener than once in three or four years, and is rotated with *jowâr* and its subordinate mixture or with *kodra* mixed with *tuver* and sesamum or with such other crops as are ordinarily grown in *besar* alluvial soil. In the uplands of the Konkan and on and under the ghâts in the Deccan Collectorates the crop is grown mostly on sloping or steep land. In these hilly tracts the land is allowed to be waste for a number of years, usually from

four to ten according to the kind of soil. When broken up for cultivation after fallow, the scrub growth and grass is cut and spread with other available rubbish evenly over the surface and burnt. Then a short rotation of crops is taken, the usual order on good upland *varkas* land being (1st) *nágli*, (2nd) *vari*, (3rd) *kodra* (*harik*), (4th) *khurásni* (niger seed). *Nágli* is grown to some extent away from the ghâts on the borders of the Deccan plains, where the rainfall is 40 inches more or less, and is there rotated with *jowár* or *bájri*, each with subordinate pulse, &c., mixture. *Khurásni* is also a common crop in these fields.

CULTIVATION IN GUJARÁT (KAIRA DISTRICT).

The nursery or seed bed is prepared with much the same care as for rice. Less manure is required. It is necessary to get the seed bed ready and the seed sown as early as possible. The seeds are small, and the seedlings when young are very tiny and easily damaged or destroyed by heavy rain. It is, therefore, important to have the seed bed in a sheltered position. The seeds are so small that only a very small seed rate is actually required. Generally, more seed is sown than is actually necessary to furnish sufficient seedlings for transplantation. The cultivator looks ahead, and considers the risks of seedlings being destroyed by insects or heavy rain. Moreover, he selects, when transplanting, only the best seedlings. Weakling plants he does not use. 4 lbs. to 6 lbs. of seed sown in a 2 *guntha* seed bed ($\frac{2}{40}$th part of an acre) will give, under ordinary conditions, an ample supply of seedlings for transplanting an acre. The seedlings are ready for transplantation when 4″ or 5″ high, and five weeks or so after sowing. The seed bed should be carefully weeded from time to time as required. The main field is got ready whilst the seedlings are growing. Manure at the rate of at least fifteen loads per acre should be carted to the field and spread evenly in May. When the soil is moistened 6 inches deep by the first rains, the light plough (*hal*) should be used twice. Afterwards in July, when the seedlings are ready for planting, the plough should be again used; and by means of the plough, harrow and plank roller, the field should be made clean, friable and smooth. The seedlings may be planted, like rice, in muddy soil during falling rain—two or three together, and 8″ or so between plants. Another plan is to use the plough for planting when the soil is dry enough to be worked properly between showers. The plough should be guided straight to open a furrow about 3″ deep. The seedlings are placed by hand in the furrow 6″ to 8″ apart. The soil moved in making the next furrow covers the roots. The covering of the roots and the levelling of the surface is properly completed by hand. The furrows are 10 inches or so apart. If the work is expertly done, the crop grows in regular

rows, the advantage of which is that the *karabdi* (narrow bullock hoe) can be used for weeding and interculture. The crop should be bullock hoed twice and hand weeded once. Dead seedlings should be replaced. Transplantation is most successful if moderate rain falls soon after, and continues with moderate breaks for some time. *Nágli* does best in Gujarát in years of heavy rainfall. The crop ripens in October.

Reaping, threshing, outturn.

The straw of a good crop is thick and very tough near the root, and is not easily reaped by a sickle. It is of poor nutritive value as fodder, and is often very carelessly harvested on this account, as well as owing to the cost of reaping. The heads of grain are, however, carefully gathered, and the straw or stubble is grazed subsequently by cattle. A fair average crop in Gujarát will yield 1,300 to 1,500 lbs. of grain per acre ; a really good crop from a fertile, liberally managed field, 2,000 lbs. per acre. The grain as threshed (the membranous pericarp adheres to many of the seeds) is worth 40 to 45 lbs. per rupee in average seasons in Gujarát.

Parching unripe grain.

The green heads of *rági* are reaped as the seeds are nearly fully formed and parched. The cultivator treats himself and passing friends to this delicacy. The practice of parching unripe grain, particularly special varieties of *jowár*, is more common in Gujarát than in any other part of the Presidency. In fact, it is an indication of affluent, easy circumstances among the Pátidár cultivators.

Cost of Cultivation in Kaira District.

	Per Acre of Field. Rs.	a.
Preparing 2-guntha seed bed and manuring it and seed	2	8
15 Loads manure per acre for field	7	8
Ploughing and preparatory tillage (three ploughings, two harrowings, levelling with plank roller)	3	8
Transplanting—4 men and 12 women—lifting seedlings from seed bed and dibbling them into field	2	8
Hand weeding once and replacing dead seedlings	1	8
Bullock hoeing twice	0	8
Removing heads of grains from straw and threshing and winnowing	3	8
Cutting straw and tying into bundles	2	4
Assessment	7	0
Cost of Cultivation per acre ...	32	0
Outturn—		
1,500 lbs. grain per acre	35	0
Straw	4	0
Outturn per acre ...	39	0

Cultivation in the Konkan.

The broadcasted crop.

It is not unusual to broadcast the first *nágli* crop taken after a long fallow on *varkas* land. The scrub growth is cut in the hot weather, and laid evenly over the surface. It is usually supplemented by branch wood carried from a distance, by dried grass and *harke* (straw of *harik*). The *rább* material thus arranged is burnt. The seed (about 12 lbs. per acre and usually mixed with ashes or fine earth to secure even distribution) is sown broadcast in the *rább* ashes and ploughed in with the first fall of rain. The surface is subsequently broken and levelled, but is usually left very rough. If ploughing is impracticable, as is often the case on steep land, the seed is covered by hand digging. The work in this case is done much better, and the surface is left fairly regular and smooth. On the more level and more fertile *varkas* lands, the land is ploughed twice as soon as possible after the first fall of rain, and worked to a fairly fine tilth. The seed is then broadcasted and covered by a light ploughing or by light hand digging, and the surface is made fairly smooth. The crop is hand weeded once, and superfluous seedlings are thinned out. No further attention is required until harvest time.

The Konkan transplanted crop is grown from seedlings which are raised in a seed bed. The *rábing* of the seed bed is considered as essential for the successful cultivation of *nágli* on the uplands as for rice in the lowlands. The field is prepared whilst the seedlings are growing. Three or four ploughings are given, and a fair degree of tilth is obtained. The best method of transplantation is to put the seedlings two or three together in holes made 3 or 4 inches deep and 6 or 8 inches apart by means of a pointed pole which is driven with considerable force into the soft soil to make these holes. The manure is applied directly into these holes. Sometimes it consists of half rotten fish mixed with ashes and sheep dung; sometimes a handful of goat or sheep manure or a piece of dried fish may be placed in each hole to half fill it. Then the two or three seedlings are inserted, and the surrounding earth pressed down upon the roots. 300 or 400 lbs. of dried fish (*kuta*) per acre is an ordinary application, and on good level land sometimes about 800 lbs. per acre are given. A less successful way of transplanting is to put the seedlings into soft mud as in the case of rice, the field having been previously manured and worked. The leaves of the seedlings lie all in one direction. The seedling grows up right as it takes root, but usually many fail to do so. If heavy rain falls immediately after planting, the soil and seedlings get washed away on steep land; and if the rain is deficient, the seedlings wilt and die. Seed at the rate of 2 lbs. per guntha is sown in the seed bed, and a 4 guntha seed bed is sufficient for an acre.

Outturn. The outturn in the uplands of the Konkan is very variable; so much depends upon season, particularly on regular, moderate rainfall at time of transplanting. The crop tests of the Presidency, which in the case of this cereal have been numerous, show that in seasons which are only moderately good, the outturn from a carefully cultivated upland field may range from 700 to 900 lbs. per acre; but the same land in a very favourable season and under similar cultivation may yield 1,300 to 1,600 lbs. grain and 2,000 to 2,400 lbs. of straw.

Harvesting and threshing. The crop is harvested with a sharp sickle, and is allowed to dry for two or three days in the field and then tied up into bundles. The grain and straw are then stacked. The bundles are carried from the field in the morning when moist with dew. If handled much during the heat of the day, the grain falls out and is lost. The grain and straw are kept in stack until *Holi* (February-March). The straw, if thus stacked, is said to be improved as fodder. This is not likely unless a certain degree of fermentation is set up, which is improbable as the grain and straw are quite dry when stacked.

In the case of all cereals the stacking of grain and straw for some time makes the threshing process easier, and this is probably what is aimed at by stacking the crop for a definite period in the Konkan.

Nágli will keep good if stored in underground pits for a very long time. It is recorded that it has been stored safely in Mysore for half a century.

PANICUM—Linn.

Spikelets small, in panicles; *lowest glume* small, *second* and *third* subequal, the *fourth* hardened in fruit and, with its pale, enclosing the grain.

1. *PANICUM CRUS GALLI*—Linn. Variety *frumentaceum*.

Vern., *banti* (Mándvi, Surat District); *Barti* or *Banti* (Poona Farm).

A tufted *annual*, smooth or hairy, height 2 to 4 feet; *leaves* rather broad; *panicles* erect or drooping, consisting of numerous, closely packed, in-curved, racemose spikes with thickened stalks (Gammie).

Banti is cultivated all over the plains of India and up the slopes of the Himalayas to a considerable height.

The grain is small, rounded at base, sharp at apex, flat on one side, smooth, shining. There are at least three varieties—a creamy white seed securely enclosed in a dull brown, membranous covering, pale yellow seed securely enclosed in a pale yellow, membranous covering; and blue grey seed similarly enclosed in a drab coloured membrane.

The total area is less than 50,000 acres. The chief centres of cultivation are Ahmedabad and the Panch Maháls in Gujarát. Elsewhere in the Presidency the cultivation is trifling. Throughout the Deccan on light land with a fair rainfall it is widely grown in little patches, often as a border with other crops.

Distribution in the Bombay Presidency.

CULTIVATION.

The land is prepared as for *bájri*. The seed is drilled with a four coultered drill, usually alone in June-July, at the rate of 6 to 8 lbs. per acre. The rows are about 12″ apart. The plants should be thinned out where the seed is sown too thickly. The plants can be readily transplanted in showery weather, and vacancies are filled up in this way.

A border or patch in a field is often grown from seedlings transplanted like *nágli* or *vari*. The drilled crop should be weeded and intercultured with the bullock hoe like *bájri*. The crop ripens in September-October. It is usually grown in the Deccan on poor, light, upland soil in parts where the rainfall is moderately heavy, and on such land a yield of 400 to 500 lbs. of grain and 1,500 lbs. of straw is a full average crop.

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2. *PANICUM MILIACEUM*—Linn.

Vern., *Ghoti sáva* (Ratnágiri); *Vari* (Ambegaon, Poona); *Dudha vari* (Ratnágiri); *Cheno* (Nadiad); *Dhengli* (Sangamner).

Annual; *stems* leafy, 2 to 4 feet high, branches springing in tufts from the ground. *Leaves* rather broad, hairy, their sheaths loose, deeply grooved and thinly clad with long, white hairs. *Panicle* open and much branched; branches slender, spreading, drooping with the weight of the grain. *Spikelets* green, oval, pointed, smooth, *the lowest glume about two-thirds the length of the third and fourth.*

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3. *PANICUM MILIARE*—Linn.

Vern., *Gajro* (*Dohad*, *Panch Maháls*) *Vari ghudi* (Ratnágiri); *Halvi vari* (Ratnágiri); *Kuri* (Dohad, Panch Maháls); *Sára* (Khed, Poona); *Vari* (Khed, Poona); *Sáva* (Ratnágiri); *Sára* (Ambegaon, Poona); *Vari maháu* (Ratnágiri).

A plant greatly resembling the last in appearance, but smoother; *panicles* denser and more compact; the *spikelets* smaller and rounder; and *the lowest glume is scarcely one-third the length of the third and fourth.*

The foregoing botanical descriptions by Professor Gammie show that considerable confusion exists in the vernacular names given in the Bombay Presidency to the varieties which he groups under the two botanical names *Panicum miliaceum* and *Panicum miliare*.

General characters of *vari*, *sava* and *cheno*.

Several varieties of each of the crops provincially called *vari* and *sáva* were under experimental cultivation at the Poona Government Farm in 1899 and 1900. The crop called *káthli* in the Mával táluka district of Poona, is very like, if not identical with, *ghoti sáva* (Ratnágiri District). *Vari* and *sáva* are hill millets, usually grown under totally different conditions of soil and rainfall than those near Poona. On the Poona Farm the plants did not thrive in the same way as under more usual conditions of cultivation. At the same time I should, without any hesitation, say that the terms *vari* and *sáva* as ordinarily used refer to two distinctly different crops according to the observation of any ordinary agriculturist. Both crops have late and early ripening varieties. On an average *vari* takes longer to come to maturity than *sáva*. The latter, I believe, has the more vigorous habit of growth, and has a peculiar lustre in the foliage which *vari* does not possess. The graceful, drooping panicles of *vari* are more evenly balanced than those of *sáva*, the latter nodding somewhat to one side. The chief difference between the two crops, from a purely agricultural point of view, is the difference in the seed. *Vari* has smaller grain than *sáva*. In each case the grain is oval, slightly pointed at each end, smooth, shining or polished. A membranous covering encloses the seed in each, and in both is fairly easily separated from the clean grain in threshing and winnowing. In the varieties of *vari* and *sáva*, which I have had the opportunity of examining, the membranous covering is darker in colour in *sáva* than in *vari*. In the former it is usually a dirty drab ; in the latter a clearer, lighter drab. The seeds of *vari* which I have seen vary in colour, according to variety, from a dull clean white to canary-yellow or very light yellow-brown. The seed of *sáva* is distinctly darker in colour, and in the lighter shades has a distinctly dirty tinge. It may be dirty white, dirty yellow, dirty orange, a bluish slate colour and a dull green, and probably other colours according to variety. *Sáva* samples are much mixed as regards the colour of grain. Professor Gammie considers *vari* and *cheno* (the Gujarát crop) as botanically identical. Agriculturally, they are very different. The latter has much bigger seed, but of the same clear colour as *vari*. It ripens much quicker, and in Gujarát grows excellently as a hot weather, irrigated crop.

The agricultural differences which exist between *vari*, *sáva*, and *cheno* are, however, no greater than those found between different varieties of other cereals cultivated under varying conditions. Thus the cultivated varieties of *jowár*, of wheat, of barley, of maize and other cereals which are referable to particular tribes are often very unlike each other from an agricultural point of view, and perhaps it is not

wrong to group together under the same head, as is done in this Presidency, the crops which may properly be classed as belonging to *Panicum miliaceum* and *Panicum miliare*.

Vari is believed to be a native of Egypt, but it must have been introduced into India at a very early date. Habitat.

In the agricultural returns the areas under *vari*, *cheno* and *sáva* are entered together. This area varies from 300,000 to about 360,000 acres annually. *Vari* and these other companion millets occupy the sixth place among the cereals of the Presidency. The cultivation of *vari* and *sává* is almost limited to the Konkan and to the ghát parts of Násik, Poona, Sátára, Belgaum and Dhárwár. These millets are grown in similar soils and under like conditions to *nágli*. Both *vari* and *sáva* can be grown from transplanted seedlings, but the latter crop is more often produced from drilled or broadcasted seed. Distribution in the Bombay Presidency.

Cultivation of Vari in the Konkan and Ghát Districts.

This cereal is a *kharif* crop, depending entirely on the natural rainfall, and is never irrigated. It is raised, like *nágli*, from *rábed* seedlings, and the cultivation of both crops is much alike. While the seedlings are growing, the field is ploughed three or four times during the first three weeks of the rains. About 1 lb. of seed per *guntha* ($\frac{1}{40}$th acre) is broadcasted on the seed bed, and a 5 to 7 *guntha* seed bed will furnish seedlings sufficient for an acre of transplantation. Transplanting is done with the same care and exactness as in the case of *nágli* or rice. The number of seedlings planted together in one hole depends upon their strength. If they have grown vigorously in the seed bed, fewer are required.

Vari is grown unmanured, the residue left of the manure applied to the previous crop (*nágli*) being sufficient. The crop is commonly hand weeded once in August. If transplanted early in July, the late varieties of the crop ripen towards the end of October. The crop is reaped with a sickle, but as the straw is not used for fodder, and it has no other economic value, except for *rább*, usually a long stubble is left in the field.

A full average crop on good *varkas* land will yield 700 to 750 lbs. grain per acre, worth usually 40 to 45 lbs. per rupee. Outturn and value.

Vari, like *nágli*, is ordinarily a poor man's food grain. It is also used on fast days by the middle and richer classes. Economic uses.

Sáva may be grown in precisely the same way as *vari* and the description of cultivation of the transplanted crops, outturn, &c., already given apply equally to both.

CHENO.—This crop is grown principally in Gujarát, chiefly in garden land, and as a hot weather, irrigated crop. The cultivation of *cheno* in Gujarát is popular, because it thrives well in the hot weather. It then provides excellent fodder in considerable quantity at a season when fodder is scarce. The cultivator of garden land is in the hot weather and at the beginning of the rains often hard pressed for fodder for his work cattle, because his energies are chiefly directed in producing market garden crops which, though very valuable, do not help him to feed the cattle which he requires for tillage and irrigation. In the Charotar villages of Baroda and Kaira *cheno* often follows ginger or other market garden crops which come to maturity in December-January.

Cultivation. When ginger or other garden crop is removed in December-January, the land is ploughed several times. When a good tilth is produced, beds are formed for irrigation. The seed at the rate of about 10 lbs. per acre is carefully broadcasted and lightly covered. Light irrigation is given as required. The crop is usually hand weeded once. If sown at the end of January, it comes into flower in March, and may then be cut green for immediate requirements. It gets fully ripe in April, and a good crop thickly covers the ground and stands about 3½ feet high. The seed is easily separated by beating small bundles of half sheaf size on a board. The straw is bound into bundles after the seed is threshed. A good crop will yield about 2 tons straw and 1,000 to 1,200 lbs. grain per acre.

KODRA—*Paspalum scrobiculatum*—Linn.

Natural order—*Gramineæ*.

Tribe—*Paniceæ*.

Kodra—Gujaráti and Maráthi.

Harik—Kánarese and Maráthi.

Habitat. *Kodra* is a native of India. *Kora*, a wild grass resembling *kodra* in the inflorescence, is common in the Bombay Presidency. All over India *kodra* is perhaps more extensively cultivated than any of the other inferior millets, the chief reason being that it is particularly well adapted for the poorest soils under favourable conditions of climate and rainfall. It is extensively grown on very poor soil in the Bombay Presidency. At the same time it is a popular and paying crop on the rich, alluvial plains of Gujarát.

General character of the plant.

A smooth, annual grass, stems numerous and branching, and 1 to 2 feet high, compressed. In height *kodra* is the smallest of the cereals. The grain head is either terminal or axillary, and consists of two or more spikes. The spikelets are arranged alternately along a common stalk in two, sometimes four, rows on one side of a flat rachis. The leaves over-top the inflorescence and the grain head is often partially concealed in the leaf-sheath. The grain is small, more oval than round, brown, smooth, enclosed in a light or dark brown membranous covering.

Distribution in the Bombay Presidency.

Kodra takes the seventh place among the cereals of the Presidency. The area varies from year to year. From 250,000 to 350,000 acres are annually sown. Gujarát claims the largest area. Elsewhere it is chiefly grown in Ratnágiri, the uplands of the Konkan and the ghát parts of the Deccan. It is grown everywhere as a rain crop, entirely dependent upon monsoon rainfall.

Season.

Cultivation in Gujarát.

Kodra is a very important crop in the *goràdu* soils of the Kaira District, and also in similar alluvial soil in the adjoining Baroda Territory. If grown alone *kodra* is considered an exhaustive crop, but in Gujarát it is never so grown. The usual mixture is *kodra*, *tuver* and *tal*, with a sprinkling of *ambàdi* (*sheria*, Guj.), *i.e.*, Bombay hemp. This mixture is grown often year after year in the same field, without apparent diminution of outturn or exhaustion of soil if the fields are manured with fair liberality and properly tilled. In low lying damp fields in Gujarát rice and *kodra* are grown mixed in unembanked land. This mixed crop is called *vagadu*.

Gujarát cultivators believe that there is no advantage in preparing a field well for *kodra*. The crop likes a firm seed bed, and should be early sown, and the plough is rarely used in Gujarát for preparatory tillage. The bladed harrow is used instead. Soon after the first fall of rain, it is used to loosen the surface soil and prepare a friable, shallow seed bed.

This implement (*karab*) should be worked several times during preparatory tillage. The seed is drilled with the *tarfin* (three-coultered drill). The seed for the mixed crop is generally mixed before sowing. Each crop of the mixture is, therefore, found in all rows. A common seed rate per acre would be :—

12 lbs. *kodra*.
2 lbs. *tuver*.
$\frac{1}{3}$ to $\frac{1}{2}$ lb. *tal* (sesamum).
$\frac{1}{2}$ lb. *sheria*.

After drilling the seed, the field is levelled with the *samár* (plank roller). Subsequently, the crop should be hand weeded once about a month or six weeks after sowing and bullock hoed two or three times. The bullock hoe, if the weather permit, should be worked as soon as the lines of seedlings are distinctly seen in straight rows. If there are any gaps in the rows, seedlings can be successfully transplanted in wet weather. In an ordinary season *kodra* sown in the third week of June in Gujarát is in flower in the third week of August. After this, tillage operations should cease.

Harvesting, threshing, outturn.

In Gujarát the *kodra* harvest generally comes before that of *bájri*. The latter crop is, however, sown seasonably later. Early in October *kodra* is generally ripe. It is reaped with a sickle and tied into bundles and, when dry, threshed by trampling of bullocks in the usual way. The results of a crop test show below the seed rate and outturn per acre of a good Kaira crop in a fair season :—

Mixture.	Seed rate per Acre. Lbs.	Grain per Acre. Lbs.	Straw or Useful By-product per Acre. Lbs.
Kodra	12	985	1,304
Tuver	4	265	232
Tal	⅝	130	*Nil.*

first class crop of *kodra* with subordinate mixture will yield in *goràdu* soil in BarodaTerritory or in the Charotar villages of Kaira-

	Per Acre. Lbs.
Kodra	1,200
Tuver	600
Tal	160

Cost of Cultivation in Gujarát.

	Per Acre. Rs. a. p.
Proportionate value of manure applied once in three years	3 0 0
Preparatory tilling, 3 harrowings	0 14 0
Sowing and covering seed	0 6 0
Seed, *kodra* 12 lbs., *tuver* 2 lbs., *tal* ½ lb., *sheria* ½ lb.	0 6 0
Bullock hoeing three times	0 14 0
Hand weeding twice	3 8 0
Harvesting and carrying various crops of mixture to threshing floor	3 12
Threshing and winnowing various crops of mixture	3 4 0
	16 0 0
Add—Government Assessment	7 0 0
Total Cost of Production ...	23 0 0

The grain as well as the straw of kodra contains in some seasons a poisonous narcotic principle. For this reason care is taken, at least in the Konkan, to prevent cattle trespassing into *kodra* fields. In Gujarát the poisonous and non-poisonous grain is respectively distinguished in the bazar as *mitha* and *mina*, but they cannot be distinguished by eye inspection or in any ordinary way. The poisonous principle in the seed and straw is probably due to an alkaloid developed under particular conditions of climate and seasons. It is certain that *kodra* grain and straw is only poisonous in particular seasons. Damp, cloudy weather towards harvest time, a damp season and a damp undrained soil are apt to produce poisonous *kodra*.

A poisonous principle in the grain and straw of kodra.

Cultivators in Gujarát claim that diseased grain can be detected as it is threshed on the threshing floor. The bullocks treading out the grain feel the effect of the poison from the dust which rises as the grain is being trampled out, and the driver of the bullocks is also similarly affected.

New *kodra* grain is not considered such a wholesome food as old. *Kodra* should be cleaned of the husk as required. The cleaned grain rapidly deteriorates if it is kept. It is generally a food consumed by poor people of inferior caste.

Cultivation in Uplands of Konkan and Ghát Districts.

Kodra is the third crop taken after a long fallow, the previous crops being *nàgli* and *vari*. *Varkas* land exhausted by the cultivation of these crops is sown with *kodra*. In order to get a good crop of *kodra* (*harik*), *varkas* land should be well ploughed and otherwise well tilled. Generally, no manure is given. The seed is sown broadcast, at the rate of 15 to 20 lbs. per acre ; afterwards the land is sufficiently worked and the seed is carefully covered. One hand weeding, if necessary, is given. The crop is sown in June-July, and is reaped in November with a sickle. It is allowed to lie in bundles of sheaf size, exposed to the sun for a week, and is then stacked. It is threshed by trampling on a threshing floor under the feet of bullocks.

Setaria—Beauv.

Inflorescence, forming a dense, cylindric spike, each *spikelet* being surrounded at the base by deciduous bristles which vary in length in different forms of the same species.

Setaria Glauca—Beauv.

Vern., *Barati*, Poona District.

An annual grass, 1 to 2 feet high, slender, densely tufted. *Leaves* pale green, rather weak and narrow, slightly hairy. *Panicle* yellow,

narrow, compactly cylindrical. 1″ to 6″ long, erect; *bristles* a little longer than the *spikelets* which are ovoid. *Glume* covering the grain transversely wrinkled. (Gammie.)

The seed is not so large as that of some kinds of Italian millet. It is flat on one side, otherwise tapers from a rounded base to a sharp point which is slightly hooked. Colour variable, generally yellowish-green, some seeds being of lighter colour than others and lighter towards the apex or point than elsewhere.

Habitat. This grass is wild in the plains and to moderate elevations in the hills all over India. In Australia and America it is considered a good fodder grass. In the latter country it is known as bottle or pigeon grass.

General character of the crop. A good crop stands about 2 feet high. The plants have enormous tillering power. A thick crop can, therefore, be got from a small seed rate, provided the seed is evenly scattered in sowing. The stalks are very fine, the leaf growth considerable, and the fodder at least good. The outturn of fodder per acre is not, however, heavy.

Distribution in Bombay soil suitable. This grass is sparingly cultivated in the hilly parts of the Deccan on comparatively light soil with moderate rainfall.

Cultivation. *Barati* is a rain crop, sown in June-July, and reaped in October-November. The field is prepared with the harrow, and should be clean. The seed is small, and requires careful sowing. If it can be evenly broadcasted, it is better to sow in this way than by seed drill. If a seed drill is worked, one with coulters close together should be used. A seed rate of 5 to 6 lbs. per acre of seed is sufficient, if the seed is evenly distributed. The seedlings are small and delicate when young, but when once they begin to tiller, a dense growth soon covers the ground. The crop needs no further attention till harvest time.

ITALIAN MILLET—*Setaria italica*—Beauv.

Natural order—*Gramineæ*.

Tribe—*Paniceæ*.

Kàng (Gujaráti); *Kàng, Ràla, Bhàdli* (Maráthi); *Navani, Ràla* (Kánarese).

Annual, almost smooth grass. *Stems* 2 to 5 feet in tufts. *Leaves* rather long and broad. *Sheath* smooth, with a bearded mouth. *Inflorescence* with a lobed surface, nodding or altogether drooping, according to the development of the grain, from 2″ to 6″ or more long. yellow, yellow brown, dirty brown or greenish brown in colour; length of bristles very variable, but, as a rule, shorter than the spikelets in well developed, and longer than the spikelets in poorer examples. (Professor Gammie.)

The grain is very easily rubbed out from the head of grain. It varies in size and colour according to variety. The seed is oval, more pointed at one end than the other, smooth, shining. The more common colours are creamy white, dirty creamy white, yellow orange, light red brown. In one variety brownish black glumes enclose creamy white seeds.

Origin.

Dr. Watt states that this millet is found wild in India in the Himalayan range. It was cultivated at a very early period in China, Japan and the Indian Archipelago, and its cultivation spread westward from these centres.

Distribution in the Bombay Presidency.

Kàng is cultivated all over India, but in no part is the cultivation very important. In the Bombay Presidency the crop is annually becoming more popular, and the area has considerably increased within recent years.

The Gujaràt areas are very small. In the Deccan the crop is important in Sàtàra and Ahmednagar. The Karnàtak Collectorates are the chief centres of cultivation. Belgaum and Dhàrwàr each grow over 70,000 acres and Bijàpur over 20,000 acres. The total for the Presidency exceeds 200,000 acres annually.

General character of the plant.

Kàng is a quick growing cereal and a suitable crop to grow after a period of famine or scarcity. It produces a good deal of grain and a fair amount of fodder in quick time. It thrives best on medium light soil, and does better than other millets with deficient rainfall. The straw makes good fodder.

The straw of a good crop stands 5 or 6 feet high, and the spikes are 7″ long. In a poor crop raised under unfavourable conditions of soil and climate, the straw and heads of grain are much shorter. Some Bombay varieties have shorter stalks, smaller heads of grain and smaller seeds than others.

Cultivation in the Karnatak.

The land is prepared in the ordinary way by once ploughing and by two or three harrowings. Generally, no manure is given. The crop is sown with the drill usually in July-August. The four-coultered drill is used. The rows are 12″ to 14″ apart, and the seed rate is 6 to 10 lbs. per acre. Usually, no subordinate mixture is sown with *kàng*. The crop is hand weeded and intercultured with the bullock hoe like *bàjri*. It ripens in three months, and is cut very close to the ground with a sickle. The reaping consists in partly cutting the straw and partly uprooting the plants. The spikes of grain are cut off and threshed under the feet of bullocks like *bájri*. The straw is so fine that there is no particular advantage in trampling it into *bhusa* in the threshing process.

A Dhárwár crop tested in 1894 yielded as under :—

Seed rate.	Grain per Acre.	Straw per Acre.
Lbs.	Lbs.	Lbs.
6½	843	2,631

PIGEON PEA—*Cajanus indicus*—Spreng.

Natural order—*Leguminoseæ.*

Sub-order—*Papilionaceæ.*

Tribe—*Phaseoleæ.*

Gujaráti, *Tuver*; Maráthi, *Tur*; Kanarese, *Togari.*

Origin. Equatorial Africa is believed to be the original home of this pulse. It has long been cultivated in Africa and Asia, and in historic times its cultivation has extended to the West Indies, where it is now a common pulse.

Varieties. Duthie and Fuller state *C. flavus* and *C. bicolor* are in the North-West Provinces recognized as two botanical varieties. The former is called *thur*, the latter *arhar*. The standard of the papilionaceous flower in *arhar* is veined with purple, whilst in *tuver* it is plain yellow.

In the Bombay Presidency there are two varieties—(1) a variety with white seed grown mostly in Gujarát; (2) a variety with red or light brown seed grown to a slight extent in Gujarát and in general cultivation throughout other parts of the Presidency. These varieties appear to hybridize freely when grown mixed. The seed of the hybrid is much lighter coloured than the red, being usually white-marbled with red. The red seeded variety does not grow well in the black soils of Surat and Broach. In the Deccan experimental trials have proved that both varieties appear to thrive equally well.

General habit of growth. The extent and habit of growth of *tuver* varies greatly on different soils and in different seasons. In rich deep soil in a favourable season *tuver* grows into a much branched shrub, sometimes 6 or 8 feet high, with a stout stem near the root. In Bombay it is almost always grown subordinate to, or mixed with, other crops. Its period of growth is much longer than that of the other crops with which it is grown. *Tuver* is a strong feeding, deep rooted plant which is not easy to suppress even if the season is specially favourable to other crops with which it is mixed. When such are reaped, the *tuver* has not usually assumed any great vigour of growth, but soon after, the greater air space given, promotes a rapid growth of side branches, and in good soil in a favourable season the crop will soon completely shade the ground. The long tap roots extend far into and open out the

subsoil. They seek out moisture, and plant food there. The crop resists drought in a remarkable degree, and in deep soil continues to thrive right through the *rábi* season, though sown usually in June. It litters the surface soil with a heavy top dressing of fallen leaves as it ripens, and, like other leguminose plants, adds to the soil's stock of nitrogen. *Tuver* is a favourite crop with cultivators, and there is good reason that it should be so, for it stands in the forefront amongst pulses as a restorative, rotation crop.

Distribution in the Bombay Presidency

Statistical returns give an annual area which generally exceeds 600,000 and sometimes approaches 700,000 acres. These are estimates of actual area sown. Thus if a field has *tuver* in every fourth row, only a quarter of the area of the field is returned as occupied by *tuver*. In favourable soil and in a favourable season it branches out, and might be considered a second crop, occupying practically the whole area of the field. Therefore, it would be more correct to estimate its area as that of the fields in which it is grown, and that area is probably four times that of the statistical area. The crop is of much more importance in Gujarát than the statistical area figures indicate. In many *bájri*, *jowári* and *kodra* fields in Ahmedabad, and Kaira especially, there is a decided sprinkling. In Surat every *jowár* field has subordinate *tuver*. The Broach crop is mostly *rabi*, *tuver* and sesamum being a common mixed crop in that district sown about September. All the Deccan districts grow *tuver* extensively. Ahmednagar and Sholàpur grow most, Poona least. All three districts of the Karnátak have extensive areas. The crop is not of much importance in the Konkan.

Soils.

Tuver grows to greatest perfection in the deep alluvial soils of Ahmedabad, Kaira and adjoining Baroda Territory. The *besar* soils (medium clay loams) in the Charotar villages of the two latter districts suit the crop best. It does exceedingly well on black soil of fair depth, particularly if the *rábi* rains are full average. On lighter soils throughout the Deccan it is extensively grown, but, except in the most favourable seasons, grows as a puny plant on such soils.

Mixtures and rotations.

It is, perhaps, unnecessary to refer to these, as they have been incidentally noticed in describing the various cereal crops. In *bájri* or *jowàr* fields *tuver* usually occupies separate rows. Sometimes, however, the seed is sown mixed. When *kodra* and *tuver* are grown together, the seed is mixed before sowing ; thus *tuver* and *kodra* plants grow in every row. Sesamum and *tuver* and rice and *tuver* are also common mixed crops in Broach and Surat, the latter mixed crop being grown on unembanked fields.

Cultivation.

The *tuver* participates in the general tillage of the principal crop with which it is grown. This tillage has already been described for the various cereals. The seed rate varies from 1½ lb. per acre for a row crop to 2 or 3 lbs. per acre when grown mixed with rice or sesamum or *kodra*. There is no harm done in sowing an extra pound or two of seed per acre. Superfluous seedlings are easy to remove. The strongest and the healthiest should be left. In poor soil the plants may be left 6 inches or so apart or even less in the rows. In deep soil in good condition, they should be thinned out to 12″, 15″ or even 18″ apart. *Tuver* is generally left more or less to take care of itself. This it is well able to do. There is a common country saying in the Deccan that the more *tuver* is trampled and broken when the cereal crop is reaped, the greater will be the subsequent development of the branches, flowers and fruit. This is probably true to a certain extent. The pods begin to ripen in January. Flowers and ripe pods may always be found on the same branch between January and March. It is impracticable to leave the crop until all the flowers produce ripe legumes. Successive crops may be gathered green or ripe. Green pods give seeds which are used like green peas as a vegetable. Pods when quite ripe should not be left very long ungathered, otherwise they open and shed their seed. Ripe pods gathered by hand are carried home and the seed beaten out with a short stick. In March the plants are cut at the root. It requires a sharp sickle for the purpose. They are tied into small bundles and carted to the threshing floor at once, a coarse cloth being spread in the bottom of the cart to catch seeds which shell out. The bundles are stacked on end for a few days, the green leaves dry, and the ripe pods open more or less. The pulse and leaves and husks of pods are easily threshed by beating the bundles sharply on a log of wood. The *bhusa* when separated by winnowing provides excellent fodder. The stalks are used for fuel, for making baskets, for wattling the sides of the carts, and when well grown are sold to be made into charcoal for gun powder. The plant is rich in potash, and this possibly adapts it specially for the last named purpose.

Outturn. It is difficult to estimate what an average yield of *tuver* really amounts to. 100 to 150 lbs. per acre would be considered a good yield from medium black soil in the Deccan from a crop occupying every fourth row in a *bájri* or *jowár* field. In the Charotar villages of Kaira a good yield of *tuver* in a mixed crop often amounts from 800 to 1,000 lbs. per acre. On the Poona Government Farm in medium black soil *tuver* subordinate to *bájri* in every fourth row has repeatedly yielded

between 500 and 600 lbs. per acre. The highest yield was 787 lbs. per acre; but in this particular crop the *bájri* was poor owing to the character of the season, whilst the *tuver* was excellent.

The crop has been grown alone in various experimental plots at the Nadiád Farm since 1891. The seed has been sown in rows, about 3½ feet apart. The yield in one year was 2,200 lbs. per acre, and generally has been about 2,000 lbs. per acre. The experience at Nadiád has proved that *tuver* can be safely grown alone on good deep alluvial soil and, when thus cultivated, is profitable.

Tuver as a split pulse is a common human food. The outer integument of the seed with part of the kernel is a favourite food for milk cattle. Such is sold under the name of *chuni*. The feeding value is variable, because the proportion of husk and of meal is by no means constant. *Chuni* containing much husk has poor feeding value. Economic uses.

Tuver is usually worth 35 to 40 lbs. per rupee, but in out districts it is sometimes very cheap—50 lbs. or more per rupee. The crop is usually grown without much risk of damage by disease or other mishap. Very cold nights do harm, also cloudy weather. In each case the flowers do not properly fertilize. Value.

GRAM OR CHICK PEA—*Cicer Arietinum*—Linn.

Natural order—*Leguminosæ*.

Sub-order—*Papilionaceæ*.

Tribe—*Vicieæ*.

Gujaráti, *Chana*; Maráthi, *Harbhara* or *Chana*; Kanarese, *Kadle*.

This pulse is sometimes called Bengal gram to distinguish it from *kulthi* (*Dolichos uniflorus*), which is known as gram or horse-gram in Madras. Gram is probably indigenous in South Eastern Europe or South Western Asia. Its cultivation in India is ancient. The Sanskrit name is *chanaka*. It was cultivated by Greeks in Homer's time. Its cultivation in Egypt dates back to at least the early Christian Era. The Romans called it *cicer*. It is called *arietinum* from the fancied resemblance of the seed to the head of a ram when first forming in the pod. Origin.

There are at least four varieties in cultivation in the Bombay Presidency. They differ only as regards the colour of the seed. The plants in other respects cannot be distinguished. The seed of the different varieties varies as follows in colour:—(1) black, (2) dark red or reddish-brown, (3) yellow or yellowish-red, (4) white or creamy white. The three first are generally grown indiscriminately together. The yellow gram of Gujarát is larger than that produced in the Deccan. This may or may not signify difference of variety. Yellow gram, if true to Varieties.

variety, commands a higher price than the mixed. White gram is grown on a small scale in the Ahmednagar district. It is probably the same variety as that described by Duthie and Fuller as Cabuli gram ; but the seed of the Deccan crop is not larger than that of the more common varieties.

Distribution in the Bombay Presidency.

The area varies considerably from year to year according to season. In years of heavy September and October rainfall the gram area is generally larger than in years when the late *kharif* rains are scant. But this is not always the case. The cultivators may consider the season more suitable for wheat and as dry crop wheat and dry crop gram are grown largely on the same description of soil, and in the same tracts of country, these crops are more or less interchangeable. Usually the total area of gram in the Presidency ranges from 600,000 to 700,000 acres. The Panch Mahâls grows the largest area in Gujarát, but the crop is also important in Ahmedabad and Kaira.

In the Konkan little gram is grown. The crop is extensively cultivated in all districts of the Deccan and Karnátak. The areas range between Collectorates from 40,000 to 70,000 acres. Ahmednagar is the most important district, and grows sometimes over 100,000 acres.

Soils suitable, mixtures, rotations.

Gram in the Presidency is always a *rabi* crop. It is grown in three ways—(*a*) as a dry crop in deep black soil when usually it is the sole crop of the year ; (*b*) as a dry second crop usually after rice in rice beds, but occasionally, as in Panch Mahâls, on ordinary dry crop land after a *kharif* crop of maize ; (*c*) as an irrigated crop liberally manured and regularly watered.

Dry crop gram does best on deep retentive black soil, such as the wheat lands along the Tápti in Khándesh and the Godávary in Ahmednagar. It also does well on alluvial soil of rice beds when such are clay loams. These are naturally fairly retentive of moisture, and on account of favourable position usually hold sufficient moisture to properly mature the crop, even if the rainfall after sowing is trivial in extent as it generally is. In parts of the Deccan gram is grown on medium black soil ; sometimes entirely as a dry crop, but oftener is helped by one or two waterings. The cultivation is risky on such land unless the cultivator has means of irrigation at hand. He generally has this either from a well or canal, and, failing a sufficiency of moisture in the soil from natural rainfall, he irrigates once or twice. The field is not laid out for regular irrigation. He leads the water over the surface in the best way he can if he is compelled to irrigate to save his crop when it shows signs of withering. Gram which is regularly irrigated is fairly commonly met with in the Deccan, especially under well irrigation. Medium black soil of fair depth and resting on *murum* is best suited. Such land grows in

rotation with gram irrigated crops of wheat, *jowár*, onions, sweet potatoes, and other vegetables, but is rested from irrigation every second or third year, and then ordinary rain crops are grown.

Gram is most commonly grown alone. The practice of growing wheat or barley mixed with gram, which is common in the North-West Provinces, is unknown in the Bombay Presidency. In Khándesh linseed in separate rows is occasionally grown in the gram fields. In the Ahmednagar District and in the Karnátak safflower is the subordinate row crop.

A good rotation crop for reasons given.

Gram is everywhere recognized as a valuable rotation crop, either on dry crop land or under irrigation. It is restorative like other leguminose crops. A good crop is dense and shades the ground and, therefore, suppresses weeds. On dry crop black soil it is practically a fallow crop sown after thorough tillage. The succeeding crop, therefore, is benefitted to a considerable extent.

Cultivation on Black Soil as a Dry Crop.

Gram and wheat are, according to the character of the season, interchangeable, and both crops receive the same preparatory tillage. That for wheat has already been fully described, and need not be repeated. The field should be ready for sowing by the end of September. The crop is sown then or during October. If sown later, there is risk of the soil moisture failing before the crop reaches maturity. A heavy two coultered drill is used for sowing. The rows are generally about a foot apart. The usual seed rate is 40 to 50 lbs. per acre. A crop sown in October ripens in February. Meantime, it is rarely weeded.

Pruning gram.

When the seedlings have begun to branch, the leading shoots should be nipped off in order to encourage branching and the formation of more flowers and fruit. Care must be taken that the plants are not cropped too much. A healthy, vigorous crop on rich soil can stand a good deal of pruning. But an ordinary dry crop that scarcely covers the soil will not stand so much. The work costs nothing. The farm servants will do it in their own time if allowed to take the nipped shoots. These are sun dried, stored and used as required as a green vegetable. The effects of pruning against non-pruning were tested at the Poona Farm for three consecutive years, with the results tabulated below. The crops were grown under light irrigation on medium black soil in good condition :—

	Outturn of Pulse per Acre.		
	1893-94.	1894-95.	1895-96.
	Lbs.	Lbs.	Lbs.
Nipped crop	1,375	1,825	1,650
Unnipped crop	1,090	1,071	1,545

A useful by-product.

In walking through a crop of gram it may be noticed that boots or clothes are discoloured by an acid substance which is abundant if there is dew on the foliage. This under the name of *ámb* is used medicinally in the Deccan. It consists of oxalic and mallic acids, with a little acetic acid. It can be collected by spreading wet cloths over the foliage and wringing out the absorbed *ámb*.

Harvest.

Gram, as it ripens, changes to a rich yellow brown colour. Many of the leaves drop off and litter the ground. It is reaped with a blunt sickle, or is mostly uprooted. The reaped handfuls are made into little heaps, and, if there is wind, a clod of earth is put on each heap to keep it from being blown about.

Threshing and winnowing.

Gram *bhusa* good fodder.

The crop needs three or four days' exposure to the sun before it is threshed. It is threshed under the feet of the bullocks and winnowed in the ordinary way. The fine chaff makes excellent fodder. It has an acid taste, and, if mixed with the *bhusa* of wheat, gives the whole mass an agreeable flavour which all kinds of farm stock relish. The coarser stalks with roots have poor feeding value, and are usually separated during the winnowing process. 500 to 600 lbs. pulse per acre may be considered a fair average dry crop on black soil under ordinary cultivation. But, as already noted, a liberally managed irrigated crop on good soil will yield much more.

Cultivation in Rice Beds, Gujarat.

The field is ploughed once or twice after the *kharif* crop is removed. If twice, the second ploughing is across. The seed is then drilled, sometimes broadcasted. The drilled crop needs about 50 lbs. seed per acre, the broadcast crop more. An ordinary two rowed heavy drill may be used, but oftener the seed is passed through a single tube fixed behind a plough, which is worked to a depth of 3 inches. The seed drops in the furrow made by the plough, and is covered by the soil moved in making the next furrow. The surface is then more or less levelled, but usually is left rather rough. If, however, the soil holds sufficient moisture, the crop thrives. It requires no further attention till harvest time, except that it should be nipped as previously described. A good crop yields 800 lbs. pulse and about the same weight of fodder.

Cultivation of Deccan Irrigated Crop.

The field is either directly manured or in good condition from previous applications. It requires careful tillage. It should be ploughed and worked until the soil is smooth and friable to a depth of 3 or 4

inches. The seed is best sown by hand in the furrow behind a plough. It should be sown in every furrow. 60 to 70 lbs. seed per acre will be required. The soil moved by the plough covers the seed to the depth of 3 inches. The rows are about 9 inches apart. Part of the soil is afterwards moved by hand rake or hand hoe to level the surface and form small ridges round the compartments for irrigation. Water channels must also be formed by opening with the plough and deepening and finishing with a hand spade. If the field is fairly level, the arrangements for irrigation may be simplified by forming long narrow beds along the least slope, generally along the whole length or width of the field. Such beds may be 3½ or 4 feet wide. They are divided from each other by ridges of soil, and water admitted to each bed in turn should flow slowly along the entire length of each. An elaborate system of beds and water channels is not so much required for gram as for other irrigated crops, because if gram is sown in damp soil in October, it rarely needs irrigation oftener than perhaps three times.

If weeds appear soon after germination, as they are certain to do if the crop is manured with farm yard manure, such should be removed as early as possible. One hand weeding is sufficient. The crop needs no further attention except nipping and watering until harvest time.

Diseases, blight, &c.

Irrigated gram must not be grown too often in the same land. Such a course causes diseased conditions. The crop withers in patches long before it reaches maturity, and the pods when examined are either empty or contain shrivelled seeds. The roots rot, so that plants are easily uprooted. The crop to a certain extent is delicate. Cold is harmful. Frost is fatal. Cloudy weather does harm, and heavy rain, when the seedlings are small, is disastrous. The crop in Gujarát, like *láng* (*Lathyrus sativus*), is sometimes infested with grubs which eat into the pods and consume the seeds and find their way out again as the crop ripens. In the Deccan in average seasons the crop is fairly hardy and not liable to many risks or mishaps.

Economic uses.

The gram plant is useful in a variety of ways. It is used green as a vegetable—both foliage and grain. The ripe grain is used for *dâl* or is eaten parched or made into sweetmeats. Gram is extensively used to form at least part of the concentrated daily ration for horses, and is an excellent food for fattening sheep. Gram which has been seasoned for some months is best for the two latter purposes. Such pulse is always in request and usually dear. In towns it is rarely less than 24 to 28 lbs. per rupee, and often is dearer.

Cost of Cultivation—Dry-Crop Gram, Khándesh.

	Per Acre. Rs.	a.	p.
Clearing stubbles of previous crop	0	6	0
Harrowing three times in hot weather	0	12	0
Ploughing once	1	8	0
Harrowing four times during rains	1	0	0
Drilling and covering seed	0	9	0
Cost of seed 45 lbs.	2	0	0
Harvesting, drying and carting to threshing floor	1	4	0
Threshing and winnowing	1	0	0
Total Rs.	8	7	0

CHICKLING VETCH—*Lathyrus sativus*—Linn.

Natural order—*Leguminoseæ.*

Sub-order—*Papilionaceæ.*

Tribe—*Vicieæ.*

Gujaráti, *Láng* ; Maráthi, *Lákh.*

Habitat. This pulse is indigenous from the Caspian Sea to the North of India, and has spread as a weed of cultivation. It is cultivated extensively throughout the North of India, where it is known generally by the vernacular name *kesari* or a corruption of that word.

General character of the plant. The plant is a procumbent annual which, if once seen, cannot, on account of its peculiar foliage, be confused with other cultivated pulses. The pods are about 1 inch long. They contain four or five seeds. These are ovate or wedge shaped, flattened on two sides, purplish grey in colour, and variegated or marbled. It is generally known that the seed contains a poisonous alkaloid principle and that the habitual consumption of this pulse or its continual use as food for a few months causes paralysis of the lower extremities. The alkaloid is volatile and destroyed by heat. Therefore, if the *dâl* of *láng* be properly cooked, there is less risk of bad consequences. This pulse is only eaten by the poorest people. It is exported from Bombay to Zanzibar, and is probably used there as food for coolies.

Distribution in the Bombay Presidency. Broach is the chief centre of cultivation. This collectorate generally grows 40,000 to 50,000 acres annually. Surat and Násik grow 3,000 to 4,000 acres each. In other districts the areas cultivated are very trifling.

Mixtures. *Láng* is almost invariably grown alone. Occasionally a slight admixture of *láng* may be found in gram (*Cicer arietinum*) fields, but the admixture is accidental and not intentional.

Láng thrives best on deep, retentive, black soil. In the Deccan it is chiefly a second crop in rice fields, whereas in Gujarát it is generally the sole crop of its year, although occasionally, like *rál*, it is grown as a second crop in rice beds. In Broach in wet seasons fields, which become water logged and too wet for cotton in the *kharif* season, are sown with *láng*. *Láng* is a hardy pulse and easily cultivated. Some authorities state that it will grow successfully on soils unsuited to any other pulse. In Duthie and Fuller's "Field and Garden Crops" its suitability for heavy clay soils is referred to, and it is further stated that if the seed is sown broadcast on miry ground, the crop is not so injuriously injured as other crops by the subsequent hardening and cracking of the surface. Soil suitable.

Cultivation in Broach.

In this district the crop responds to careful cultivation and liberal treatment. It is usually grown on lowlying fields which are liable to be flooded by heavy rains. It often happens that a field intended at the beginning of the season for cotton is sown with *láng*. Therefore, tillage operations begin by ploughing soon after the first fall of rain. The field may be ploughed twice, and if the rainfall prove unfavourable for cotton, it is kept for *láng*, and is repeatedly harrowed as occasion permits during July, August and September. The tillage thus given is thorough, and all weeds are destroyed. Generally no manure is applied. The cultivator knows that a good crop of *láng* on clean land is a very good preparation for cotton in the following year, and he prepares the field carefully for *láng* for this reason and also because there is a direct profit from increased outturn. The crop is sown late in September or early in October. The usual seed rate is 35 to 40 lbs. per acre. The seed is sown usually through a single tube fixed behind the plough. It is dropped in the furrow made by the plough. The seedlings come up more or less in rows, but not in such distinct lines as when seed is sown by an ordinary coultered drill. The rows are about a foot apart. The surface is levelled and pressed immediately after sowing by the plank roller. The field is generally so well prepared that no hand weeding is required and no further attention is needed till harvest time. A good crop forms a thick close mass over the whole surface, and smothers such weeds as attempt to grow and, when reaped, leaves the surface as clean as that of a fallow field. The crop ripens in February about four and a half months after seed time. It is sufficiently ripe when the foliage begins to turn yellow. It is always reaped before it is dead ripe. A blunt sickle is used, and the crop is partly reaped and partly uprooted. It is formed into small heaps in the field, and Harvest.

allowed to dry for a week. Then the heaps are turned, and, after a few more days' exposure, the crop is ready for threshing. It is threshed out under the feet of bullocks, and winnowed in the ordinary way. In a well grown crop with even germination and a full plant the weight of pulse per acre should be about equal to the weight of *gotar* (*bhusa* fodder). The fodder is considered to have high nutritive value, and in ordinary seasons it is readily saleable at 120 to 160 lbs. per rupee. It is reserved specially as food for work cattle at busy seasons. The pulse is worth 45 to 55 lbs. per rupee according to season.

Threshing.

The fodder.

The following tabulated statement gives outturns and results from full average crops tested in different years in the Broach District :—

Seed rate per Acre.	Outturn per Acre.		Value of Outturn per Acre.
	Pulse.	Fodder.	
Lbs.	Lbs.	Lbs.	Rs. a. p.
40	925	1,323	32 4 8
41	995	1,405	30 14 7
41	1,068	1,320	40 13 0

Cost of Cultivation.

	Per Acre. Rs.	a.	p.
Three ploughings between June and September	2	8	0
Three harrowings, June to September	0	12	0
Sowing with plough and covering seed with *samár*	1	2	0
Cost of seed	1	0	0
Reaping, gathering and turning heaps of crop and carting to threshing floor	1	4	0
Threshing and winnowing...	1	2	0
Add—Government Assessment ...	18	12	0

VÁL—Dolichos lab lab—Linn.

Natural order—*Leguminoseæ.*

Sub-order—*Papilionaceæ.*

Tribe—*Phaseoleæ.*

Gujaráti, *Vál;* Maráthi, *Pávta;* Kánarese, *Avare.*

Origin. *Vál* is found wild in India—its original home—and its cultivation is estimated as beginning 3,000 years ago.

Vál has a more twining and climbing habit of growth than any of the other common pulses. The leaves and young tissues are very cellular and soft, and the crop is, in consequence, often a prey to caterpillars and other insects. The flowers are in most varieties white, but purple in one climbing variety of vigorous habit of growth. The pods are rather flat, fairly broad, scimitar-shaped, tipped with the hardened base of the style, and contain three to five seeds which vary in size, shape and colour according to variety. The seeds are of three distinct types—(*a*) small, slightly flattened, oval; (*b*) large, full-bodied, rounded, oval; (*c*) still larger, flattened, oval. The usual colours of seed are white, creamy-white, kháki, pale brown, mahogany-red, brown, dark-brown, black or purplish-black. The hilum is pure white in all the Bombay varieties. The fodder of *vál*, when cut when the plants are in flower, is excellent for all farm animals. General character of the plant.

The total area is about 80,000 acres annually. The most important centres of cultivation are the Surat District, the three collectorates of the Karnátak, Ratnágiri and Kolába. The crop is grown to a limited extent in all the other districts of the Presidency. Distribution in the Bombay Presidency.

Numerous varieties of *vál* are cultivated in the Presidency. One variety—Surti *pápdi*—is grown extensively in garden land in the Surat District and as a vigorous climber in the backyards of the households. It has special value on account of the tender, green vegetable which it yields. The beans are plucked early, and used like French beans. The variety grown in rice fields in the Surat District as a second crop is a bitter variety, called *kadva vál*. Another bitter variety with smaller pods is sometimes drilled with rice and *tuver* in unembanked fields in June-July in Southern Gujarát. Varieties.

The principal crop is the *rábi* crop, and it usually is a second crop in rice fields. It is either sown alone or with the castor oil plant (the dwarf variety) occasionally in ordinary dry crop fields. *Vál* is sown among the other pulses subordinate to *jowár* or *bájri*. In the *bátha* (river side) alluvial land of the Tapti, *vál* (Surti *pápdi*), castors (large variety) and *tuver* are very common subordinate crops to *jowár*. When the *jowár* is reaped, a long stubble, 3 feet to 4 feet high, is left. This stubble with the vigorous growing castor oil plants and the *tuver* afford support to the climbing *vál*, and heavy successive crops of green beans are plucked between November and March. The soil is of sandy consistence, but the permanent water level is not far from the surface, and *vál* does not suffer in ordinary seasons from any lack of moisture. The more common crop grown in the *rabi* season in rice-beds requires soil of different consistence. The most suitable soil for the *rábi* crop is black soil or at least clay soil, very retentive of moisture Rotation, mixtures, soils.

and situated in a low-lying damp situation. In highly assessed garden land *vál* is sometimes taken as a catch crop when the opportunity occurs. It is sown as speedily as possible after the previous crop is removed, and, if this is done, the natural moisture in the soil is generally sufficient to bring the *vál* to maturity. A crop grown in this way has a restorative effect on garden land, and if the crop shades the ground, as probably will be the case, weeds are suppressed.

Cultivation of the Rabi Crop.

As soon as possible after the removal of the rain crop (usually rice), the land is ploughed and cross ploughed. The plough is again worked a third time, and the seed is then dropped into the furrows through a single seed tube attached to the plough. If *vál* is sown alone, generally the seed rate is 50 lbs. to 60 lbs. per acre. If *vál* and castor beans are sown together, the seed rate should be 40 lbs. *vál* and 10 to 15 lbs. castor beans per acre. The rough surface after sowing is generally pressed down with a plank roller or light log of wood. The crop gets no weeding or other attention until harvest time. It is fully ripe when the leaves turn yellow and drop off, and should then be reaped close to the ground with a sickle. Generally, beans are plucked previously as they ripen. If the field holds sufficient moisture to fully mature the crop, ripe beans may be plucked through a period of two months. A very good crop of *vál* after rice will yield 1,300 lbs. of pulse and an equal weight of useful fodder per acre. The average in the Surat District for all experiments up to 1896 was 658 lbs. pulse per acre. The pulse is worth 45 to 50 lbs. per rupee ordinarily.

Diseases, &c.

Vál is a delicate crop in many ways. It is on account of its tender tissues peculiarly liable to attack by insects, especially caterpillars. They destroy the foliage. A grub eats into the pods, and destroys the seeds. The crop is damaged by cloudy weather, the effect being that the flowers fall off, and the fertilization is imperfectly completed. Cold is harmful and frost fatal. In the Surat District a practice prevails of growing a border of *san* (*Crotalaria juncia*) round the crop of *vál*. The *san* grows thick and tall, and protects the *vál* to some extent from cold.

KULTHI—Dolichos biflorus or *uniflorus*—Linn.
Natural order—*Leguminoseæ*.
Sub-order—*Papilionaceæ*.

Gujaráti, *Kulthi*; Maráthi, *Hulga*; Kanarese, *Hulle*.

There are apparently two cultivated varieties :—

Dolichos uniflorus—Sub-erect.
Dolichos biflorus—Twining.

General character of the plant.

The plant grown in the Bombay Presidency has a fairly stout stem near the root. The branches are very numerous, and when no other support is afforded, they twine very promiscuously together. The foliage is very pale green, and, when young, is exceedingly tender in its tissues. The flowers are yellow, the pods are flattish, re-curved, 1 to 1½ inches long, and contain about six seeds. The seeds are shining, flattened, kidney shaped, and vary in colour and in size. One variety has fairly large purple-brown seed, another a smaller seed of the same colour. A variety grown sparingly in the Ahmednagar and Kaira Districts has creamy-white seed. The variety in commonest cultivation in India has grey, variegated seed.

An important crop in Madras.

The crop is a very important one in the Madras Presidency, where it takes the place of gram and is called horse gram.

Distribution in the Bombay Presidency.

Kulthi takes the third place among the pulses of the Presidency, and, according to statistical returns, occupies over 500,000 acres annually. It is, however, almost always a subordinate crop, generally occupying every fourth row, and the actual area over which this pulse is sown probably exceeds two million acres.

In Gujarát, Ahmedabad grows a small area. The cultivation is very important in the Deccan, particularly in the Khándesh, Násik, Ahmednagar and Sátára Districts. In the Karnátak, Belgaum and Dhárwár each grow 55,000 to 60,000 acres annually, and Bijápur 20,000 acres. In the Konkan the pulse is only important in Ratnágiri.

Season, mixtures, soils.

The principal cultivation of *kulthi* in Bombay is in the *kharíf* season as a row or mixed crop, subordinate to *bájri*. It is occasionally grown in the *rábi* season as a second crop in rice fields and sometimes alone or with rows of niger seed as a *kharíf* crop. In Madras it is used as a green manure crop to some extent. It is very sparingly cultivated for the same purpose in Bombay. *Kulthi* is essentially a light soil crop, and is extensively grown on the light red stony soils of the Deccan. It does well also on poor sandy soils. It only requires a moderate rainfall, and succeeds better than any other pulse in light soil which is in poor condition.

Cultivation in the Deccan.

Kulthi participates in the general cultivation given for *bájri*. The light soil fields in which *kulthi* is grown are rarely manured oftener than once in three years, and then only get light dressings. The land may be ploughed, but is generally prepared for sowing by working the heavy-bladed harrow (*vákhar*) two or three times in the hot weather

and again two or three times after rain has soaked the soil in June. The mixed crop is sown in July, generally about the middle of the month. A four-coultered drill is used. The seed may be mixed before sowing, in which case mixed plants are found in all rows. Sometimes the *kulthi* is sown alone in every fourth row. A common seed rate for the mixed crop in light or medium light soil would be—

Bâjrî	6 to 8 lbs. per acre.
Ambâdi (hemp)...	1 lb.
Kulthi	1½ to 2 lbs.
Niger seed (*khurâsnî*)	½ lb.

Outturn. The crop is generally bullock hoed twice with the *koipa*, but is not usually hand weeded. A good outturn per acre of *kulthi* from the above seed rate in a favourable season would be 70 or 80 lbs. pulse. The crop, if sown in July, will be ripe at the end of October or early in November. The *bhusa* or chaff obtained from *kulthi*, when threshed under the feet of bullocks, is of very fine quality, and if the fodder is cut when the plant is in flower, it is excellent for all farm animals; but the weight of fodder obtained per acre is light. The pulse is usually cheap, about 50 lbs. per rupee, and when boiled is used to a considerable extent as food for farm animals.

The fodder.

CLUSTER BEAN—*Cyamopsis psoralioides*—D. C.

Gujaráti, *Guvár*; Marathi, *Gavár*; Kanarese, *Chavlikái*.

Origin. This pulse belongs to the tribe *galegeæ* of the papilionaceous division of the *leguminoseæ*. It has never been found wild anywhere, and it is not known with certainty where it originated. One species of the genus is Indian, the only other African. It is cultivated in many parts of India.

Distribution. In the Bombay Presidency it is a crop of very minor importance, except in Gujarát. In that province it is extensively grown. The statistical area returns for Gujarát show an annual acreage under this crop of over 20,000 acres, but as *guvár* is usually sown subordinate to other crops, it is actually grown over a much wider area than the statistical figures indicate. Experimental trials in the Deccan have proved that the plant grows much less vigorously there than in Gujarát.

Varieties. Several varieties have been identified in the Charotar villages of Kaira and Baroda Territory.

I. *Pardeshi.*—A sprinkling is sown in *kodra* and other cereal *kharif* crops. In the fertile alluvial soil of the Charotar villages the *Pardeshi* variety grows about 6 feet high. The pods are gathered

usually green and used as a vegetable. Two *Pardeshi* sorts are known—(*a*) *Khagali*, with hairy leaves. This is considered a superior variety. (*b*) *Teliu*, with glabrous, oily-looking leaves. The seeds of both sorts have a yellow tinge.

II. *Sotia Guvár.*—This variety grows 8 to 10 feet high. The pods are used as a vegetable. The crop is extensively grown in the garden lands of Gujarát. It is sown amongst ginger to give shade. When the pods are plucked, the side leaves are stripped off, and left on the surface as green manure for the ginger. In the garden lands of Surat it is grown mixed with cucumbers, being sown usually in May and irrigated until the rains come. The seeds are yellowish in colour and small.

III. *Deshi* (sometimes called *boot* is the common variety, with violet-tinged seeds, which is sown as an ordinary dry crop, subordinate to *bájri*, and grows to a height usually of $4\frac{1}{2}$ to 5 feet or so. The seed and foliage are extensively used as cattle food in Gujarát, but the green pods are considered inferior as a green vegetable.

Soils suitable.

The plant does not thrive on very retentive soil. In fertile free working garden soils throughout Gujarát it grows well, and luxuriantly in the deep, alluvial, sandy loams of Northern Gujarát, particularly when such are worked as "garden" lands, and get the liberal treatment usually given to such.

In such land *guvár* is grown sometimes specially as a green manure crop. The seed is thickly broadcasted early in June. The crop may give some direct return in the shape of green pods for vegetables, but when it is in full vigour of growth, it is uprooted, the stems broken up, and the side leaves stripped off. The whole is placed as a litter on the surface and then ploughed in. *Guvár* is specially suitable as a green manure crop, not only because it belongs to the *papilionaceæ*, and therefore increases the soil's stock of nitrogen; but it is a herbaceous plant, comparatively free from crude fibre when young, and therefore rapidly decays in the soil.

MATH—Phaseolus aconitifolius—Jacq.

Natural order—*Leguminosecæ*.

Sub-order—*Papilionaceæ*.

Tribe—*Phaseoleæ*.

Gujaráti, *Math*; Maráthi, *Matki*; Kanarese, *Madaki*.

Origin.

This pulse is believed to have come into cultivation much more recently than other pulses cultivated in India. It is grown in all parts of India, but is not cultivated to any great extent in other countries.

General character of the plant.

This pulse can easily be identified from the other pulses cultivated on account of its deeply-indented, aconite-shaped leaves and the trailing habit of the stems which branch and extend along the ground in all directions. A well grown plant has stems 2 to 3 feet long. The flowers are yellow and small. The pod is straight, distinctly indented to form a compartment for each seed. Seeds five to seven in a pod, drab or light-brown or purple-brown, small, oblong.

Distribution in the Bombay Presidency.

This pulse is the fourth in importance in Bombay. The annual area is sometimes nearly 300,000, but varies to a considerable extent with the character of the season. *Math* is grown to a considerable extent in all districts, except the Konkan.

The Deccan produces most, then Gujarát. The most important districts are Ahmedabad (50,000 acres), Kaira (25,000), Khándesh (20,000), Ahmednagar (40,000), Poona (28,000), Sholápur (25,000), Sátára (60,000). In the Karnátak, Dhárwár grows 12,000 acres and the other two collectorates less.

Mixtures, soils.

It is only grown as a rain crop. *Math* is rarely, if ever, sown alone. It is a common, subordinate crop with *bájri*. It is, like *kulthi*, essentially a light soil crop, and gives its best outturn on the deep, alluvium sands or sandy loams of the Ahmedabad and Kaira Districts. In the Deccan Districts it is sown, like *kulthi*, mostly on light, stony, more or less upland soil, and on such land does not yield nearly so well as in the fertile plains of Northern Gujarát. It manages to thrive, however, fairly well in soil which is in poor condition. Heavy rain is very harmful to this pulse. It does best with a well distributed rainfall of about 30″.

Cultivation in Gujarát.

Math participates in the general cultivation given to *bájri*—the principal crop which has already been described. *Math* ripens after *bájri*, and is usually reaped in November-December. A fair yield in an average season would be 120 lbs. pulse per acre from a seed rate of 1½ lbs. The pulse is usually worth 40 to 45 lbs. per rupee. In Gujarát *math* when ground into coarse meal is used with cotton seed, oil cake, &c., as food for milch and work cattle.

Outturn value.

Cattle-food.

MUG—(Greengram), *Phaseolus mungo*—Linn.

Natural order—*Leguminoseæ*.

Sub-order—*Papilionaceæ*.

Tribe—*Phaseoleæ*.

Origin.

Gujaráti, *Mag* ; Maráthi, *Mug* ; Kanarese, *Hesaru*.

Mug is a native of India, has been cultivated for at least 3,000 years, and is grown in all parts of India and also in Africa, particularly in the Nile Valley.

General character of the plant.

This pulse closely resembles *udid* (*Phaseolus radiatus*). It is a hairy, sub-erect branching annual, with fairly large entire trifoliate leaves. The yellow flowers are crowded in a cluster. The pods are 2″ or more in length, and contain twelve or fewer seeds. The seeds are rounded, very slightly oblong, and, according to variety, may be very dark marbled green, pale green, brown, purplish-brown, or pale yellow-brown in colour.

Distribution in the Bombay Presidency.

This pulse is sixth in importance in Bombay. The statistical returns give an annual area of about 200,000. But *mug* is often sown as a mere sprinkling in *jowári* and other fields, and probably this sprinkling actually covers an area of perhaps 1½ million acres. The pulse is grown more in Dhárwár and Bijápur than in other districts. The other more important centres of cultivation are Ahmedabad, Khándesh, Ahmednagar, Sátára and Belgaum.

Season, mixtures, soils, &c.

In Dhárwár, Kolába and Kánara *mug* is grown in the *rábi* season as a second crop after rice. Its chief cultivation is, however, in the *kharif* season. As a *rábi* crop it is grown alone. As a rain crop it is grown subordinate to *jowári* and other cereals. *Mug* does best on deep good soil of fairly dense consistence, such as the *besar* soils of Gujarát or ordinary black soil. Soils which are suitable for *jowár* are also suitable for *mug*. The plant does best with a well distributed rainfall at about 30″ to 35″. Heavy downpours of rain are very disastrous to this pulse, particularly at flowering time.

Cultivation.

Mug when grown in the *rábi* season as a second crop after rice is cultivated in the same way as *vál* (*see* description given). The seed rate is less than for *vál*, 15 to 20 lbs. per acre being sufficient. The preparatory tillage should also perhaps be more careful. *Mug* needs a fairly fine seed bed. In the Deccan this pulse is sometimes sown alone in the *kharif* season as a catch crop before sugarcane and other irrigated crops which are planted in the *rabi* season. The seed is drilled with a four-coultered drill at the rate of 15 to 20 lbs. per acre on well prepared soil. One hand weeding is given, if necessary. The pulse soon covers and shades the ground, and smothers weeds. It is either allowed to grow to maturity, or the pods are plucked and used as a green vegetable, and the fodder afterwards cut green. The crop is often attacked by caterpillars. The cultivation of *mug* as a subordinate crop has been already described under *jowári*. From a seed rate of 1½ to 2 lbs. per acre an outturn of 150 lbs. to 200 lbs. pulse per acre may be expected in a favourable season. *Mug* and its near relative *udid* are considered the best pulses for split *dál* for human food. *Udid* is perhaps generally considered best.

UDID—*Phaseolus mungo.* Var., *Radiatus*—Linn.

Gujaráti, *Adad*; Marathi, *Udid*; Kanarese, *Uddu.*

General character of the plant.

This pulse resembles *mug* in general appearance. It is more hairy, and the leaves are lighter green in colour. The pods are shorter and stouter than those of *mug*, and the seeds are oblong, rounded, larger than *mug* and dark brown, nearly black, slightly marbled in colour. The hilum is white. *Mug* and *udid* are near relatives, and are considered as belonging to one species. Both are cultivated all over India.

Distribution in the Bombay Presidency.

The statistical returns show that the area varies considerably from year to year according to season. It ranges from about 250,000 acres downwards. *Udid* is mostly grown as a subordinate crop with *jowár* and other cereals, and the actual area over which the seed is sown is probably four to six times the area recorded, the recorded areas being estimates of the actual areas which would be occupied if *udid* was the sole crop. *Udid* is a very important pulse in the black soils of Khándesh. It is also grown fairly extensively in Násik, Sátára, Belgaum, Thána and Ahmedabad. In other districts it is of minor importance.

Season, mixtures, soils, &c.

Udid, like *mug*, is grown mostly as a rain crop, subordinate to *jowár*, but also, like *mug*, is grown alone to a small extent in the *kharif* season and over a considerable area in the *rábi* season and chiefly as a second crop after rice. It thrives best under precisely the same conditions of soil, climate, &c., as *mug*, and the cultivation as described for *mug* is applicable to *udid* in all particulars.

CHOLA—Vigna catiang—Endl.

Natural order—*Leguminoseæ.*

Sub-order—*Papilionaceæ.*

Tribe—*Phaseoleæ.*

Gujaráti, *Chola*; Maráthi, *Chavli*; Kanarese, *Alsandi.*

Origin.

Chola is a native of India, and is cultivated generally throughout the plains. Several varieties are known which differ in the colour of the flower, the colour of the seed and the length of the pod.

General character of the plant.

Chola resembles *mug* and *udid* in habit of growth. The branches are, however, more climbing or twining, and the leaves and stalks are hairless. The flowers are borne in clusters at the top of the peduncle, and, according to variety, are either very pale blue or reddish-purple inside. The former are yellowish outside, and this colour is most observable as the flowers fade after fertilization. The peduncles are long, and so also are the beans. They are, therefore, easily seen in clusters of three to six above the level of the twining crop. This is particularly noticeable in a long-podded variety grown by market gardeners as

a green vegetable. The long straight pods are indented on each side, so that each seed occupies a separate cell so to speak. The seeds are numerous in each pod, and are oblong-rounded. One Bombay variety has large pale yellow seed, with a purple margin circling the white hilum. Another variety is of the same colour, but the seeds are much smaller. A third variety has light purple seed with drab hilum. The seed of a fourth variety is dull yellow. A fifth variety has blue-black seed, with small dirty white hilum.

Distribution in the Bombay Presidency.

The cultivation of this pulse is not extensive. The total area does not exceed 25,000 acres annually. It is grown to the greatest extent in the Kaira, Khándesh, Belgaum, Bijápur and Thána Districts.

Season, mixtures, soils.

Chola does not yield so well as *mug*, *udid* and other hardier pulses as a subordinate crop with cereals under unfavourable conditions of rainfall and season. Its cultivation is, in consequence, restricted. It is grown with other pulses subordinate to *bájri* in light alluvial soils in the Kaira District. It does better in moderately light soil than in soil of heavier or denser consistence. It is grown alone in the *kharif* season in garden land to produce a green vegetable—so-called French beans—and in the *rabi* season is grown, like *mug* and *udid*, to a limited extent as a second crop in rice fields. As a sole crop in the *kharif* season it grows rapidly, soon shades the ground with a thick mass of growth, which, if cut as green fodder, is excellent in moderate quantity for cattle, especially milk cows. The crop is liable to be damaged by caterpillars, the leaves when young being soft and tender.

Fodder.

The cultivation as described for *mug* is applicable to *chola*.

LENTILS *Ervum lens or Lens esculenta*—Linn.

Natural order—*Leguminoseæ*.

Sub-order—*Papilionaceæ*.

Tribe—*Vicieæ*.

Gujaráti, *Masur*; Maráthi, *Masur*; Kanarese, *Channangi*.

Origin.

This plant is a native of Western Asia, Greece and Italy. It has long been cultivated in Egypt, and was brought from there to India, and is now grown as a cold season crop all over the country. It is specially important in the Central Provinces, Madras and North-West Provinces.

General character of the plant.

This plant is the smallest of the Bombay pulses, and resembles gram (*Cicer arietinum*) in its habit of growth. The plant is more erect and more branched. It can be distinguished from other pulses by its tiny leaflets and its small two-seeded pods.

The flowers are pale purple in 2 to 4 flowered racemes. The seeds of the common variety are round, but flattened and purplish-brown, slightly marbled. A less common variety has large round very flat seed, slightly wrinkled and of the same colour as the common variety.

Distribution in the Bombay Presidency.

The total area is less than 20,000 acres. The crop is only important in Násik, Belgaum and Poona.

Season, mixtures, soils.

Masur is grown generally alone and always as an unirrigated *rabi* crop. In the Poona district it is the sole crop of the year, and is grown chiefly just under the eastern slopes of the ghats. It is there rotated with dry crop wheat. The district is favoured by heavy monsoon rains and usually with good showers in October and November. The soil is mixed black, but only of moderate depth.

Cultivation.

The land is left uncultivated during the heavy monsoon rainfall. In September and October a plough is worked repeatedly until the land is clean and in fair tilth. The seed is drilled in October in rows a foot or less apart. The seed is small, and 20 to 25 lbs. per acre give a sufficient seed rate. The seed should not be deposited too deeply. Often a heavy log is drawn over the surface after the seed is sown to smooth the surface and press down the soil to conserve moisture. No hand-weeding or interculture is given. The crop ripens in 3½ months. A good outturn in a fair season from the poor "rabi" lands in which *masur* is usually grown will not exceed 300 lbs. per acre. No other pulse would thrive so well under the same conditions of soil and climate. The amount of fodder obtained per acre is small.

SESAMUM OR GINGELLY OIL-SEED, *Sesamum indicum*—Linn.

Tal, Gujaráti; *Til* or *Tili*, Maráthi; *Yellu*, Kanarese.

Habitat.

This plant belongs to the natural order *Pedalineæ*. It is cultivated throughout the tropical regions of the globe, and is wild in the island of Java. Dr. Watt thinks it is indigenous in India.

General character of the plant.

Sesamum is an annual herbaceous plant which when well grown is 3½ to 4½ feet high. The stems are erect, but branch freely if the plants get room. The fruit consists of a four-celled capsule, oblong, quadrangular, and opens at the top. The seeds are numerous, oval, flattened, shining, and either white, grey, reddish brown, dark brown or black according to variety. They are smaller than linseed.

Varieties and conditions under which different varieties thrive best.

It is difficult to classify the varieties. There is very little difference between them in the appearance of the leaves, flowers, fruit or mature plants. The white-seeded variety of the Deccan matures

about a month earlier than the black and a fortnight earlier than red-seeded variety if sown early in the monsoon. But this white-seeded variety is different from the Gujarát variety with similar seed. Experimental trials have proved that the white Deccan variety does not thrive nearly so well in Gujarát as the local white variety. Varieties with seed of any of the recognised colours thrive if sown alone or subordinate to other crop early in the monsoon on certain descriptions of soil, principally light soil. The same remarks apply to such crops as are sown in soil which is generally much heavier, midway between the *kharif* or *rabi* season or in the *rabi* season. The seed of the monsoon varieties will not, however, produce a satisfactory crop if sown in the *rabi* season, and the *rabi* varieties are equally unsatisfactory if sown in the monsoon. There is evidence, in fact, that, whatever the colour of the seed may be, a variety which is habitually grown on certain kinds of soil in a particular district, at a certain season may not thrive if tried in another district, even though the conditions of cultivation are not materially different. White *til* contains a larger percentage of oil than seed of darker colour, and the residue oilcake is also believed to be superior.

Three varieties grown at the Poona Government Farm were found by Dr. Leather to have the following analysis :—

	White Seed.	Black Seed.	Red Seed.
Moisture	4·87	5·42	5·37
Oil	48·13	46·50	46·20
Albuminoids ...	22·50	25·81	21·03
Mucilage, &c. ...	14·05	9·06	15·87
Woody fibre	4·49	6·52	4·18
Ash	5·96	6·69	7·35
	100·00	100·00	100·00
Containing nitrogen...	3·60	4·13	3·37
Do. sand ...	·37	·66	1·35

These varieties were sown in adjoining plots on the same day—21st June. They ripened as under :—

White Til ...	... 14th October.
Red Til ...	... 2nd November.
Black Til ...	... 19th November.

Distribution in the Bombay Presidency.

From 300,000 to 350,000 acres are grown in the Presidency annually. In certain districts *til* is chiefly grown as a subordinate crop, therefore the area figures can only be approximately accurate. It is an important oilseed in all districts of Gujarát. In the Deccan, Khándesh is the principal centre of cultivation. But Násik, Ahmed-

nagar and Sholápur have also considerable areas. It is grown throughout the Karnátak, but to the greatest extent in Dhárwár. The Konkan areas are not extensive.

Soils suitable.

The *kharif* crop requires a totally different kind of soil to that found most suitable for the *rabi* crop. *Til* as a rain crop likes a sandy or light soil, whereas the crop which is sown in August-September or later grows best on black soil or on such soils as are retentive of moisture.

CULTIVATION IN KAIRA.

The Kaira cultivation is typical for the *kharif* crop. *Til* is there sown subordinate to *bájri* on *gorádu* (sandy loam) soils. The other subordinate crops are the usual pulses and fibre plants. The *til* seed rate is ¼ lb. or less per acre. For early sowing the black, brown or grey varieties are considered preferable to the white. *Til* participates in the cultivation given to the principal crop, and, if sown as early in the *kharif* season as is practicable, will be ready for harvest in September-October. A good outturn of *til* as a subordinate crop is from 80 to 120 lbs. per acre.

Cultivation of the *rabi* crop.

Til as a *rabi* crop is extensively grown alone on black or medium black soil. The rotation crops are cotton and *jowár*. In the *til* year there is a good opportunity of thoroughly cleaning the land during the early monsoon months, because *til* is not sown until September. A field for *til* should be thoroughly clean, and, when such is the case, the crop is an exceptionally good rotation crop with cotton. The advantage of growing *til* is chiefly on this account and not because it is directly particularly profitable. The crop is not exhaustive. The field should be got ready by repeated ploughings and harrowings during June, July and August. This tillage should produce a perfect state of tilth and at the same time a tolerably firm seed bed. The seed should be drilled. In the Deccan a four coultered drill is used, and the rows are about 13″ to 14″ apart ; ¾ to 1 lb. seed is sufficient seed rate. The seed is small, and, to secure even distribution, should be mixed before sowing with finely powdered dry cowdung manure or ashes. *Til* likes a firm seed bed. The seed should be sown shallow and covered lightly with a brush harrow made of *bábhul* branches. In sowing *til* the iron shares should be removed from the coulters of the drill to lessen penetrating power. The seed germinates slowly and often irregularly unless the soil moisture is sufficient. Heavy rain after sowing is usually disastrous, and cloudy weather, when the plant is in flower, does harm. The crop only needs light showers and a retentive soil to bring it to maturity. It is, however, like some other oil-seeds, a delicate crop to grow. Superfluous seedlings should be thinned out and the crop hand weeded once and bullock hoed twice. If sown in September, the

crop is ready in January. It is ripe when the leaves turn yellow and capsules get mottled with black spots. Sometimes patches in a field, especially if the soil is variable, ripen prematurely. Such patches must be harvested as they ripen. If the plants get over ripe, the capsules open, and the seed is certain to be lost before the crop reaches the threshing floor.

Harvesting, threshing and winnowing.

It is best to harvest the plants by uprooting. They should, as they are uprooted, be shaken over a large cloth spread in the field behind the harvesters, and moved from time to time as required. Thus the seed from such capsules as have opened is collected. The plants should be bound into small bundles, and carted the same day or the following day to the threshing floor. The bundles should be stooked up on their root ends close together on the threshing floor. In the course of ten days or a fortnight the capsules will ripen and open through the effect of sun and wind. The capsules will empty themselves by inverting each bundle and gently beating it with a stick. This may have to be repeated once or twice at intervals of a few days, especially if all the plants were not equally ripe when harvested. In any case the threshing of the crop is an inexpensive and simple process. The winnowing or cleaning of the seed is not quite so easily accomplished. It is partly effected by means of wind in the ordinary way, but the seed being light requires a good deal of sifting or winnowing to clean it properly. This is done by a *sup* which, if deftly handled, will separate all small particles of dirt and other impurity.

Cultivation in Gujarát.

In the black soil parts of Ahmedabad or in similar soil in Broach and Surat the crop may be grown alone, but it is more common to have a mixed crop of *tuver* and castors or *tuver*, *til* and *chibdi* (a small cucumber). The mixed crop is drilled in September on thoroughly prepared soil. The rows are about 2 feet apart, and the plants are thinned out 8″ to 12″ apart in the rows. In an unfavourable season a field of *til* in Broach or Surat shows irregular germination and a patchy appearance. But when the season is favourable, the crop is very regular and level, and the outturn very satisfactory. The mixture of *tuver* safeguards the cultivator, because it is a hardy plant, and in the deep soils of Broach and Surat there is certain in any season to be sufficient moisture in the soil to bring the pulse to maturity, even though the mixed crop is sown as late as October. The *chibdi* is sown a seed here and there, and spreads rapidly between the rows of *tuver* and *til*, and yields successive crops of green cucumbers until the plants become yellow and exhausted. The cultivation, &c., of *til* in Gujarát is, except as regards points noted, identical with that already described for the Deccan.

In Khándesh a good crop yields from 320 to 360 lbs. per acre. The seed is usually worth from 15 to 18 lbs. per rupee, white seed being dearest. White *til* on account of its pure colour is prized for the preparation of sweetmeats. *Til* cake is worth 35 to 45 lbs. per rupee, and is an excellent feeding cake. That made from white *til* is sometimes eaten by the poorer classes. The oil is largely used in native cookery in all well-to-do households.

A crop experiment taken in the Surat District in 1895-96 gave the following outturn, &c., results from a good average crop :—

Seed rate.	Outturn of Oilseed per Acre.	Value of Outturn
lb.	lbs.	Rs. a. p.
1	372	25 13 3

In 1898-99 excellent crops of *til* were grown on the Government Farm, Surat, on good ordinary black cotton soil. The following are details of outturn and cost of cultivation :—

	Per Acre. Rs. a. p.
Ploughing	3 12 0
Collecting stubbles of previous crop	0 4 6
Sowing and covering seed	0 7 0
Seed—1½ lbs. *til*, 1½ lbs. *tuver*	0 2 6
Thinning and hand weeding	0 15 0
Interculture	0 4 0
Watching	0 10 0
Harvesting	3 4 0
Threshing and winnowing	0 11 0
Total ...	10 6 0

Outturn.	Per Acre. Lbs.	Value. Rs. a.
Til	454	28 6
Tuver	11½	0 4
Tuver bhusa	23½	0 2
Total ...		28 12

LINSEED—*Linum usitatissimum*—Linn.

Natural order—*Lineæ*.

Tribe—*Eulineæ*.

Alsi, Gujaráti; *Alsi* or *Javas*, Maráthi; *Ayashi*, Kanarese.

Habitat. The plant is found wild between the Persian Gulf and the Black Sea, and is supposed to be a native of that region. It is cultivated in India, chiefly throughout the plains. It was introduced into India by the Aryans.

Economic uses. In India it is grown entirely for its seed which is valuable on account of the oil extracted therefrom and because the residue oil cake is perhaps the most valuable cattle food which is known.

In more temperate countries the cultivation of this crop is undertaken chiefly on account of the value of its fibre which is known as flax. It is probable that the climate of the plains of India is unsuitable for the production of strong fibre from this plant, and therefore it is right to grow the crop for its seed only.

General character of the plant.

Linseed is an erect annual. When sown thickly in temperate climates as a purely fibrous plant, the stems do not and ought not to branch so freely as when with a much smaller seed rate the crop is grown for its seed. In India a mature crop stands 18″ to 24″ high. The stems rise from the ground some distance, and then they branch freely. A linseed crop in flower is, during December-January, a noticeable feature of the black soil districts, particularly in Khándesh. The delicate colouring of the pale blue shining flowers, is very striking. The fruit is a capsule, and is agriculturally called a boll. It has ten divisions, each containing a single seed. These are, however, imperfect sub-divisions of five perfect cells. The capsule is sub-globose with a sharp apex. The seeds are smooth, shining, feel soapy or oily when handled, and are oval and flattened. The common variety is rich, mahogany-brown in colour, but a creamy-white variety is sparingly grown in the Bombay Presidency and to a considerable extent in the Central Provinces.

Distribution in the Bombay Presidency.

The total area in the Presidency is usually less than 260,000 acres. The dry crop *rabi* areas under linseed, wheat, gram and *jowár* are more or less interchangeable, depending on the character of the monsoon season and particularly on the late rainfall. There is very little linseed grown in Gujarát. Khándesh, Násik, Sholápur and Ahmednagar are the important centres of cultivation in the Deccan. Bijápur grows a large area and Dhárwár a fair area. In the Konkan no linseed is grown.

Soils, season, mixtures.

Linseed is only grown in the *rabi* season on deep moisture holding black soil, and is on such land rotated chiefly with wheat and gram as dry crops, sometimes with *rabi jowár*. Linseed is generally grown alone, but, as stated in the descriptions of other crops, may be a row crop, subordinate to dry crop of *rabi jowár*, wheat and gram. The special black soils of the Presidency which particularly suit dry crop wheat and dry crop gram are equally suitable for linseed. The very best class of soil is probably the deep black soil belt on each side of the Tapti in Khándesh, which may get flooded and sodden in the rains, but which retains moisture in exceptional degree in the fair season.

Cultivation. Linseed is the sole crop of its year. The preparatory tillage should begin with one or two harrowings in the hot weather, be continued during the monsoon, and should be complete by the end of September. The land may be ploughed once, but the principal tillage is done with the harrow (*vakhar*). It will produce, if worked often enough, a clean, friable, thoroughly pulverized seed bed by the end of September. In October the seed should be drilled at the rate of 10 to 12 lbs. per acre in rows about 1 foot apart. The seed should not be deposited too deeply, and should be lightly covered. If there is moisture near the surface in deep black soil sufficient to secure even germination, the crop will probably reach maturity without any mishap and without further rainfall. The field for linseed ought to be so well prepared that hand weeding should not be required. Interculture with a bullock hoe between the rows of delicate seedlings would usually be harmful, and is not practised. The crop in a good season ripens in February, and with a sickle is partly reaped near the ground, partly uprooted. The seed easily sheds from the dry plant. Therefore the crop, soon after it is reaped, should be carried to the threshing floor. When completely dry by exposure to the sun, the seed is easily separated by beating with a stick. The seed is winnowed by wind in the usual way. A good crop with full even plant on deep black soil will yield about 500 lbs. seed per acre, but the crop is precarious and often yields much less. Rain after sowing does usually more harm than good, and cloudy weather, when the plants are in flower, interferes with fertilization in a manner which is not understood. Linseed may, therefore, be considered a delicate crop, which in favourable seasons only is grown with particular success.

Diseases. A species of rust which may or may not be identical with the rust of wheat attacks this crop. The effect is that, although the crop looks comparatively healthy at harvest time, the seed vessels are either empty or contain imperfectly filled seed.

Cost of Cultivation, Khándesh.

	Per Acre. Rs.	a.	p.
Clearing stubble of previous crop	0	6	0
Harrowing three times in hot weather	0	12	0
One ploughing in rains	1	8	0
Four harrowings during monsoon	1	0	0
Manure once in three years, or, say, six loads per annum ...	2	0	0
Drilling and covering seed	0	10	0
Cost of seed 12 lbs.	0	14	0
Harvesting, carting, threshing and winnowing a crop of 400 lbs. per acre	2	0	0
Total ...	10	2	0

Ireland and Belgium are the two great European flax-growing countries.

The conditions which favour the production of the finest quality of fibre are :— Linseed as a fibre crop.

(1) Suitable soil and careful tillage.
(2) Early sowing.
(3) Proper seed rate.
(4) Harvesting the crop at the proper stage.
(5) The subsequent treatment in extracting the fibre.

The crop likes an alluvial soil of an open character, in good heart, deeply cultivated, well manured and thoroughly clean. The seed should be evenly distributed either by broad casting or drilled in rows which should not be more than 9 inches apart. Weeding is of special importance. The plant is more or less delicate, and is not able to hold its own if sown in land which is not free of weeds.

When grown as a purely fibre crop, the seed should be sown early. The growth of the plant is thus slower than if sown later, when the chill of spring has given place to the warmth of summer. The effect is that the slower vegetation of the spring months produces a stronger and more valuable description of fibre. A high seed rate is necessary to produce fibre having a long staple. If the plants come up thickly, they grow with straight slender stems, which only throw out branches near the top. The necessary seed rate is from 80 to 120 lbs. per acre—just ten times as much as that for a seed crop in Bombay. The stage at which the crop is harvested needs special attention. It may be pulled, when it has flowered, ten to twelve weeks after sowing. If harvested at this stage, the amount of seed obtained is small, but the quality and quantity of fibre obtained makes up for this loss. When the plant begins to change colour at the root, it is considered to have matured sufficiently to give the best results; but in order to get a fair quantity of seed from the crop without materially damaging the fibre, the crop is sometimes allowed to grow, until a selected capsule from a full grown plant shows on section that the seeds, though still of a deep green colour, have acquired some consistence. Then the crop is immediately pulled. The seeds ripen after the crop is harvested, but, of course, are not so well developed as those of a fully ripe crop. The uprooted crop lies in the sun two or more days, is then tied into small sized sheaves which are stooked up in the field sufficiently long to be safely stacked, or they may be carried at once to the steeping vats. The methods employed in extracting the fibre could only be generalized here, and as elaborate accounts of the whole process are given in several standard works, they need not be particularized.

It is probable that the heat of India does not favour the production of as fine a quality of flax fibre as the more temperate climates of European countries do. Moreover, the amount of seed required (Rs. 5 to Rs. 6 worth per acre) would be prohibitive with ordinary cultivators, because the cost would be grudged for a crop which, at the best, is a speculative and precarious one to grow.

SAFFLOWER, OR WILD SAFFRON—*Carthamus tinctorius*—Linn.

Gujaráti, *Kábri, Kasambi* ; Maráthi, *Kardai*, ; Kanarese, *Kusubi.*

In Gujarát *kábri* is the name given to the seed, whilst *kasambi* or *kasambo* are names applied to the crop or to the dye extracted from the petals of the flowers. In the Deccan the Maráthi name *kardai* is applied to the crop or the oilseed.

General character of the plant.

Safflower belongs to the *Compositæ*. It is an annual thistle-like plant, with stems 2½ to 3 feet high, which branch freely, particularly if the leading shoot is nipped off early. The flowers in large compact heads are either yellow, slightly tinged with orange or bright orange, yellow tinged with red. The fruit or oilseed is an achene, obovoid, angular, with a white skinning husk and dull yellow kernel.

General distribution.

Safflower has never been found wild. Its original home was probably India or Africa. It is also grown in Europe, extensively in the south of France, Spain, Italy, Southern Germany and Southern Russia. It is also grown in China and South America.

Varieties.

Two varieties are grown in Bombay—the oilseed variety, which has yellow flowers and thorny leaves; and the dye plant, which has reddish-orange flowers, and is much less thorny than the oilseed variety. It is probable that safflower, like brinjal, by high cultivation, becomes less spiny. It is frequently observed that plants which in a wild state are very spiny show a tendency to lose their spines under cultivation (Watt).

Distribution in the Bombay Presidency.

The cultivation of the dye plant is not extensive. It is confined to Gujarát and the Karnátak. Kaira is the most important centre of cultivation. The extent of cultivation and the use of the dye has declined during the last twenty years, aniline dyes having supplanted *kasambi* both in the English market and in India.

Safflower is the most important oilseed crop in the Presidency. The area is usually from 500,000 to 600,000 acres annually. The chief centres of cultivation are in the black soil *rabi* lands of Ahmednagar, Poona, Sátára, Bijápur, Dhárwár and Belgaum.

Mixtures and rotations.

The dye plant is chiefly grown in the deep alluvium loams of Kaira and Ahmedadad, generally alone as a dry crop or as a sprinkling in barley fields.

In the Deccan and Karnátak the oilseed plant is almost always a row crop subordinate to wheat, gram or *rabi jowár*, or it may be grown as a border round other crops on the headland in *rabi* fields. This border answers the purpose of a fence, as stray cattle will not trespass through its thorny leaves.

CULTIVATION OF THE DYE PLANT, KAIRA DISTRICT.

The land is generally lightly manured in May or June, and ploughed during the rains several times. The bladed harrow (*karab*) is used after the plough, and the field becomes clean and in good tilth by September. The seed is drilled in that month or in October in rows 18 to 22 inches apart. The seed rate is about 20 lbs. per acre. The crop should be intercultured with the bullock hoe twice or oftener as may be required. If the seedlings come up thick in the rows, they should be thinned out. The extent of thinning will depend upon the season. Rain rarely falls after the crop is sown, and the plants will have to depend upon the natural moisture in the soil. If this is sufficient and germination is even, the plants soon show considerable vigour of growth, and should then be allowed plenty of room to branch freely. The central shoot should be removed. Lateral branches are thus encouraged, and numerous flower heads are produced. The prunings and any seedlings which are removed in thinning the crop are used, like spinnage, as a vegetable.

Picking the flowers and making the dye.

The flowers appear late in January or early in February, and picking goes on for a whole month. Flowers are picked in the early morning and at least every second day. The flowers are easiest picked when in full bloom. They lose their colour when exposed to the sun. Therefore, flowers in full bloom should be picked at once. The plants being thorny, the pickers protect their hands with leather gloves. The bloom during the first part of the month is brighter in colour and superior to that during the latter part. The plants, as they become exhausted, do not produce flowers of such brilliant colours as when in full vigour. Cloudy weather in the flowering season is harmful. The flowers drop off before they are in full bloom. The plucked flowers (corollas), after being kept for a day, are rubbed with *til* oil—a *tola* weight to a pound of flowers—and are then dried in the sun for three days. This is the practice in Gujarát, but it is known to produce loss of colour. Drying should be done either by pressure or in the shade. When dry, the corollas are beaten into powder, sifted, and packed ready for market.

The Bombay dye inferior.

As a dye, Chinese safflower is considered superior to Indian and Bengal dye to that of Bombay, which is thought very poor.

The chemistry of the dye.

Safflower petals contain three colouring matters—two yellow and one red. The red, called carthamic acid or carthamin ($C_{14}H_{16}O_7$) is by

far the most valuable. One of the yellows is soluble in pure water, and is separated through that means from the others. It has little value as a permanent dye. The second yellow is soluble, both in alkaline and acid solutions, while the red is soluble in alkaline, but not in acid solutions. These facts indicate the manner in which each can be separated from the others.

Value of produce.

Safflower dye cakes are sold in Gujarát at 2 to 2½ lbs. per rupee. These cakes are made from the pulp from which the comparatively valueless temporary yellow has been washed. These cakes contain carthamin, as well as the more permanent of the two yellows, and form the basis required to produce the various tints of yellow, orange, pink and red so common in native-dyed cloth.

When safflower is grown alone as a dye crop, a fair average outturn on well manured, good land would be :—

Dried Flowers per Acre.	Seed per Acre.
100 to 120 lbs.	400 to 600 lbs.

Outturn.

Two duplicate well manured plots on the Nadiad Experimental Farm gave each the following results in 1891-92 :—

	Plot I.	Plot II.
Date of sowing	10th October.	10th October.
Seed-rate	15 lbs.	15 lbs.
Local estimate of crop	Average.	Average.
Outturn per acre	Seed 960.	986.
	Flowers 111¼.	115.
Value per acre	Rs. 53-10-4.	Rs. 55-2-1.

Cultivation of the Oilseed Crop in the Deccan.

Safflower, as already stated, is always a subordinate row crop in *rabi* fields of dry crop *jowár*, wheat or gram. It, therefore, participates in the general cultivation given to these crops, which has already been described. Usually three consecutive rows of safflower alternate with 9 or 15 or 21 consecutive rows of the principal crop. The safflower ripens after the principal crop. It is ripe when the stems and leaves take a yellow colour. The plants are partly uprooted, partly reaped with a sickle. They are made into heaps in the field, and a clod of earth put on each heap to prevent its being blown about by wind. After three or four days' exposure, the oilseed can be separated. A threshing floor is usually prepared in the field, and the oilseed beaten out with a stick, and subsequently winnowed.

The results of a crop test taken in 1890-91 in the Ahmednagar District, as tabulated below, are, I think, nearly average :—

Mixed Jowár and Kardai.

	Jowár.	*Kardai.*
Estimate in annas	16	16
Seed rate per acre	4 lbs.	1 lb.
Outturn per acre (grain)	664 lbs.	96 lbs.
Value per rupee	55 lbs.	48 lbs.

The seed under pressure yields about 25 per cent. of oil which has a clear straw colour, and is extensively used in cookery, as also in adulterating *ghi* and *til* oil. *Kardai*, ground-nut and *til* mixed and crushed together furnish the sweet oil of the bazars. Safflower oilcake would be a much better food than it is for milk cattle, if the tough white husk of the seed (fruit) were completely removed. Very often, however, the oilseed is partly decorticated by rough grinding between stones, and the husk separated by sifting before being pressed for oil. Cattle have to get accustomed to the cake before they eat it greedily. It has an advantage over other edible oil cakes, in that it keeps free of mould and good for months, and, moreover, is usually cheaper. The oil and oil cake.

NIGER SEED,—*Guizotia abyssynica.*

Gujaráti, *Rámtal*; Maráthi, *Khurásni*, *Kárala*; Kanarese, *Gurellu.*

This plant is a native of tropical Africa. It is extensively cultivated as an oilseed in various parts of India. Habitat.

Niger seed belongs to the *Compositæ*, and is an erect annual herb with stems 3 to 3½ feet high when well grown. The plant branches freely when it gets sufficient room. The yellow flower heads are numerous, and are each about 1″ in diameter. The fruit is a black, shining achene. General character of the plant.

A clear, limpid, pale yellow, sweet oil is expressed from the seed, and is largely used for culinary purposes. The residue oil cake, though it has a black uninviting appearance, is one of the best oil cakes for milk cattle. It is, however, very hard, and should be broken into small fragments before it is used as cattle food. The seed contains from 41 to 43 per cent. of oil, and yields in the country *ghání* from 30 to 32 per cent. of oil. Economic uses.

Gujarát grows a very limited area. The crop is of most importance in the Deccan, and is especially important in the Násik District. Bijápur grows a fair area. In the uplands of the Konkan the cultivation is fairly extensive. Distribution in the Bombay Presidency.

The crop is a *kharif* one. It is sown in June or July, and reaped in November or December. It succeeds well on the shallow black and light soils of the Deccan, particularly if a seasonable monsoon is followed by favourable late rains. *Khurásni* is extensively grown in the uplands, often on poor stony land, where it is, in rotation with the coarse hill millets, the last crop taken before the land is allowed to lie fallow. *Khurásni* maintains a vigorous growth on light land in poor condition, if the rainfall is sufficient and timely. It is more Soils, mixtures, season.

commonly grown alone than any other of the oilseeds. The yellow patches of *khurásni* form in the Deccan a noticeable feature in the landscape during September and October. In the same district in *bájri* fields it is also a conspicuous row crop, and it is found growing round the borders of cereal fields in situations subject to cattle-trespass. Cattle do not care to eat it, neither will they readily stray through it to reach the more tempting *bájri*.

Cultivation

The land is not often ploughed for *khurásni*, neither is it manured. The *vakhar* (heavy harrow), loaded with a large stone and drawn by four bullocks, is used several times in April-May. By this means 2 or 3 inches of the soil is brought into a fine state of tilth which, when the rain comes, forms a capital seed bed. The seed is drilled with a four-coultered drill in rows 11 to 13 inches apart; 4 to 6 lbs. seed per acre is a sufficient seed rate. The young seedlings, if they come up thickly, should be thinned out to give individual plants room. A well branched plant produces more seed than several straight unbranched ones. The *kolpa* (bullock hoe) should be worked to weed and loosen the soil, but otherwise the crop has to take its chance. When ripe, it is cut with the sickle, dried in the sun for a few days, and carried to the threshing floor, where the seed is flailed out with a long supple wand. The following tabulated figures show the result of careful crop tests taken in 1891-92. These crops were estimated as average :—

Seed rate.	Outturn of Seed per Acre.	Value of Outturn.	Assessment.
Lbs.	Lbs.	Rs. a. p.	As.
3	279	10 5 0	6
9	264	9 11 0	6

GROUNDNUT, EARTHNUT OR PEANUT, *Arachis hypogœa*—Linn.

Natural order—*Leguminoseœ*.

Sub-order—*Papilionaceœ*.

Bhoising, Gujaráti; *Bhuimug*, Maráthi; *Bhaimug*, Kanarese.

Groundnut is an annual herbaceous plant with procumbent branching hairy stems which, however, turn up at their growing points. The leaves are compound, and have four hairy oval leaflets which are slightly variegated in colour. The small yellow pea-like flowers are at first sessile. After fertilization, the receptacle elongates, and forces the ovary below ground, where the fruit matures 2 to 4 inches under the surface. The pod is irregularly bent and 1 to 2 inches long. It contains two to four seeds. The pericarp or husk of the ripe fruit is tough, leathery, drab grey in colour, and curiously wrinkled with

irregular deep indentations. The seeds are light brown when harvested, but get darker in colour during storage. They are somewhat irregular in shape, being flattened where they fit against each other in the pod.

Groundnut is a native of Brazil. It has long been cultivated in India, in Africa and generally in tropical countries. In India the crop is most important in the Madras and Bombay Presidencies.

Distribution in the Bombay Presidency.

The annual area has of late years been variable with a tendency to considerable decline. In 1898-99 the total area was 88,000 acres—about half the area of some previous years.

Surat is the only district in Gujarát which grows groundnut, and its area is small. In the Deccan, the Sátára area is still the most important, though it has declined greatly within recent years. Considerable areas are also grown in Sholápur, Poona, Násik and Kháندesh. In the Karnátak, Belgaum grows a fair area. In Dhárwár and Bijápur the cultivation is trifling. No groundnut is grown in the Konkan.

Soils.

The crop grows best in deep alluvial soil of sandy loam consistence, but in Bombay it is grown to a greater extent on mixed black soil. Such land under irrigation is capable of growing market garden crops. The depth of soil is usually 2 to 2½ feet with a pervious substratum of *murum* and decomposed trap which secures perfect natural drainage.

Rotations, tures.

Groundnut is an important rotation crop in garden lands in the Deccan. It is rotated with sugarcane, irrigated wheat, irrigated *jowár*, potatoes, sweet potatoes, onions, chillies, gram, &c. In Surat the garden crops grown in rotation with groundnut are *surans* (elephant foot), ginger, turmeric, yams, sweet potatoes, potatoes, cabbages, onions, garlic, &c.

Groundnut is generally grown alone, but occasionally, as in Surat, it is a mixed crop with castors.

A good crop forms a mass of matted trailing stems which completely shade the ground and smother all weeds. The advantage thus gained, together with the ameliorating benefit which the soil receives by the growth of this and some other leguminous crops, make groundnut a favourite in the rotation practised in garden land. Among garden crops it occupies the important position which gram occupies amongst dry crops. The cultivation of groundnut is only undertaken by well-to-do cultivators, and is an indication of prosperity or easy circumstances.

Season.

The crop is generally sown early in the rains, and, if late rains are deficient, it is helped by two or more waterings. In the Deccan it is sometimes sown later, and then necessarily needs irrigation during the greater period of its growth.

Manure. Sheep or goat manure applied either by folding the flock on the field or otherwise is considered specially suitable. The sheep and goats should be folded during the hot weather. If the land cannot be manured in this way, a heavy dressing (25 loads per acre) of ordinary well rotted farm yard manure should be given in May, and evenly distributed over the surface before the first fall of rain.

CULTIVATION IN THE DECCAN.

The land should be deeply ploughed as soon as the soil has been soaked 6″ or more deep with early rain. It is afterwards worked to a fine tilth by the repeated use of the bladed harrow (*vakhar*). The seed is sown between monsoon showers when the soil is dry enough to be worked by a plough. Husked kernels are sown. The husk should be carefully removed by hand and a few days only before the seed is required. 40 to 50 lbs. of husked nuts are required to sow an acre. These nuts are dropped by hand 3 or 4 inches apart in the furrow made by a 2-bullock plough. Each furrow should not be more than 3″ deep. The seed is covered by the soil moved by the plough in making consecutive furrows. If the ploughing is carefully done, the rows are about 9″ distant from each other, and are straight enough to be bullock hoed. Another method of sowing is to use a four-coultered drill. A harrow is used to cover the drilled seed. After the plough, the wooden head piece of the harrow, with the blade and prongs removed, is used to level the surface.

The crop should be weeded twice. As soon as it shades the ground, no further attention, except watering, is required.

Irrigation. The monsoon crop occupies the soil six to seven months, and in the absence of rain the land must be kept moist artificially. It is usual to give two to four waterings during the last two or three months. The land is, however, not laid out into beds for any regular system of irrigation. The water is simply led over the surface in the best way the cultivator can arrange.

Harvesting The crop is harvested; like potatoes, sometimes with a plough, but more often the field is dug over by hand with a light native pick.

A cultivator collects a large number of people—mostly women and children—and pays in kind. In order to expedite the digging, the haulms are previously reaped and removed. These, if not over-ripe and dry, form an esteemed fodder. The cultivation in the Surat District is described under that of the castor-oil plant.

Outturn. A good crop on suitable land liberally managed will, on an average, yield from 3,200 to 3,500 lbs. of unhusked nuts per acre. These figures only apply to good land. The proportion by weight of unhusked nuts to those with husk removed is as 4 to 3. This is the rate after the nuts

have been dried sufficiently for safe storage. They are usually sold unhusked, and are worth from 30 to 45 lbs. per rupee according to locality and season. The nut is often dug for home consumption before the crop is dead ripe, and the seed is either eaten raw or parched.

Groundnut is commercially valuable on account of the high percentage of oil which it contains. Senegal, Mozambique and other East African varieties contain in the kernels about 50 per cent. of oil. The Bombay and Madras varieties contain only 42 to 45 per cent. of oil. The oil.

In the hydraulic press mills of Bombay the seed is heated and crushed before it is pressed, but cold expression gives the best quality of oil. Pure groundnut oil is almost colourless with a very faint odour and taste. It is valuable in Europe for adulterating olive oil, and the darker coloured inferior kinds are used for the lubrication of machinery and other purposes. In India the oil is used in native cookery, for adulterating ghee and also as a lamp and lubricating oil.

Groundnut oil does not turn rancid quickly.

The residue cake is a very highly concentrated nitrogenous food, and in moderate quantity is excellent for milk cattle and hard worked bullocks, but, being particularly rich in albuminoids, should be fed mixed with other food of a starchy nature, such as ground maize, ground barley, &c. Oil-cake.

CASTOR OIL PLANT—*Ricinus communis.*

Natural order—*Euphorbiaceæ.*

Tribe—*Crotoneæ.*

Gujaráti, *Diveli*; Maráthi, *Erandi*; Kanarese, *Audla.*

There are perennial and annual varieties of this plant. The annual varieties grown in the Bombay Presidency are very much smaller than the perennial varieties. The latter grow with great rapidity, and a year's growth produces a tree 15 to 20 feet high. The foliage branches and stems, according to variety, may be bright pale green, or green tinged with red, bright shining red, or bronze purple. Varieties with the latter description of foliage are often grown as decorative plants in gardens. The stems of the castor-oil plant are hollow; the leaves are large and deeply [illegible] The flowers are monœcious, paniculate and terminal on the leading and branches. The fruit is a three-celled capsule, having the external excrescences, and contains three seeds. The seeds vary and in colour according to variety. They are oval, slightly flat one side, smooth, shining, and beautifully marbled with shades grey, yellow, fawn and brown. One Bombay variety has black in colour, with tiny specks of white. The perenni[illegible] Ge of growth [illegible]es best on [illegible]ate the cul- [illegible]ate of 15 cart- May. In June

chiefly grown along irrigation water channel on the borders of sugar cane and in highly cultivated market garden land, and a plant soon gains the dimensions of a tree. Perennial castors are easily cultivated and readily escape from cultivation, and consequently the plant is now found wild in many countries.

Habitat. The castor-oil plant is chiefly found wild in Abyssinia. It is a native of tropical Africa, whence it spread to Asia and Southern Europe. In Asia it is cultivated in India, in the Indian Archipelago, in Persia, Arabia, China and Japan. It is grown throughout Africa, in Italy, the West Indian Islands, and Tropical America. The perennial varieties are killed by frost in cold countries.

Distribution in the Bombay Presidency. In some years the area is as high as 180,000 acres, but has been as low as 84,000 within recent years. Surat, Ahmedabad, Dhárwár, Sholápur and Belgaum are the important centres of cultivation.

Soils, mixtures, season. The plant does best in deep free working soil. The very best crops in the Presidency are produced on the *bhátha* (alluvial) soils which fringe the course of the Tapti in Surat. In these *bhátha* lands mixed rain crops of castors, *jowári*, *turer* and *rál* are grown. The castor plants are 10 to 15 feet apart, and grow 15 feet high, and branch freely in a single season. In the alluvial garden lands of the same district a mixed crop of castors and groundnut is common.

In the sandy *gorádu* soils of Northern Gujarát a sprinkling of castors is usually found in the subordinate mixture (*kathol*) of cereal crops sown in the *kharif* season. Wherever garden cultivation is practised, castors are grown. The crop is directly remunerative, and the

Irrig shade which the plants afford to ginger, turmeric, sugarcane and many other crops is of value.

The *rabi* crop (a comparatively dwarf plant) requires soil of different character. A retentive clay soil or the soil of moisture holding rice beds are suitable. On black soil the *rabi* crop is generally sown mixed with

er, *til* or with gram, and this mixed crop is generally the sole crop

Harvesting. he year. In this case the land is well fallowed during the rains, and mor ixed seed is sown in September. In rice beds castors and *rál* or A c and gram are second crops sown in October or as soon as childre after the rice is removed.

haulms a

and dry, CULTIVATION OF THE RABI CROP IN RICE BEDS.

District is a immediately after the rice is harvested, is ploughed twice,

Outturn. A good cr with the plank roller. The seed of *rál* and castors or yield from 3, ors is mixed before sowing, and dropped through a single only apply to ed a plough. The plough makes furrow after furrow, to those with hoped into one furrow is covered by the soil moved in

making the next. The surface is levelled with the *samár*. The seedlings come up in irregular rows about a foot apart. A seed rate of 40 to 50 lbs. *vál* and 10 lbs. castors is required per acre.

Superfluous castor seedlings are thinned out. If the soil holds plenty of moisture, the seedlings are thinned 2 or 3 feet apart, and the gram or *vál* plants are all left. A good crop of *rabi* castors grows to a height of 4 or 5 feet, but when moisture is deficient, the plants grow much smaller, and are not more than 18' to 2 feet high. A crop sown in October–November ripens in February–March. In harvesting the crop the bunches of capsules are cut off in the field and spread on the threshing floor until quite dry. The seed is separated by beating with a stick. The stems are used for fuel, and cattle will eat the leaves.

The following figures show the results of a crop experiment on castors after rice grown in Broach in 1891-92. The results may be taken as average for black soil in a fair season :—

Seed rate in lbs.	Date of Sowing.	Date of Harvest.	Outturn of Seed. Lbs. per Acre.
33	October.	Early March.	525

The oil was extracted from the above quantity of seed, and was thereafter boiled to purify it for three hours. The result was :—

301 lbs. of purified oil.
286 lbs. of oil-cake (*khol*).
38 lbs. waste.

In the previous year a crop test gave results as tabulated below :—

Outturn of beans per acre		455
Oil extracted therefrom		178
Khol (oil-cake)		246⅔
Value of oil	Rs.	23-7-0
Value of *khol*	„	2-8-0

Castors have been grown alone for some years on the Nadiad Farm. The land is deep sandy loam. It is well cultivated during the rains, and the seed is drilled at the rate of 10 lbs. per acre in rows 4 feet apart in September. The other crops of the rotation are manured, but not the castors. The crop is intercultured repeatedly with the bullock hoe (*karabdi*) after the seedlings are a few inches high. The crop usually ripens in February. The best outturn obtained was 1,390 lbs. beans per acre, and this was in a specially favourable year.

Cultivation of the Kharif Crop.

The perennial variety is hardy, and its vigorous habit of growth helps it to succeed in any fairly deep soil. It, however, does best on rich garden land, freely manured and watered.

The Surat castor-groundnut mixed crop is taken to illustrate the cultivation of the *kharif* crop. Old farm yard manure at the rate of 15 cart-loads or more per acre should be given and spread in May. In June

the land should be ploughed and harrowed repeatedly, and got into fine tilth. If by means of irrigation this can be done in May, so much the better. The land is now laid out for irrigation into beds 12 ft. by 8 ft. is a common size. In the beds the groundnut seed is dibbled in twos about a foot apart between holes. Castor seed is dibbled in twos 9 ft. apart along the *bándh* which divides two lines of beds. Thus the castor plants are 9 ft. apart in one direction and 8 ft. apart in another. Hand weeding is required until the groundnut shades the ground. The crop requires no further treatment except irrigation every ten days after the rains cease. Successive crops are got from the castors. The first fruits ripen in December. Afterwards the bunches of capsules should be plucked as they ripen. The plants grow to a height of 10 to 14 ft., and are in bearing for several months.

A subordinate crop of castors of the above class grown under irrigation at the Surat Farm yielded 767 lbs. beans per acre, worth Rs. 43-14. A good groundnut crop with the castors would yield 2,500 lbs. nuts per acre.

Oil and oil-cake.

The oil from castor beans is largely used for lighting purposes, and to a considerable extent as a lubricating oil by railway companies and others. The oil-cake is not edible, but is one of the most concentrated manures, known to the native cultivators, and is largely utilized as such in garden and sugarcane cultivation. It is worth in the Deccan 50 lbs. per rupee, whereas in Gujarát it can now (1900) be got at 80 lbs. per rupee. In former years it was much cheaper. In the Deccan the Kunbi prepares the oil at home. The seed is first baked, then crushed in a mortar. The crushed seed is boiled in water, and the oil is skimmed off as it rises.

SUGARCANE—*Saccharum officinarum*—Linn.

Natural order—*Gramineæ*.

Tribe—*Andropogoneæ*.

Us, Maráthi; *Sherdi*, Gujaráti; *Kabbu*, Kanarese.

General character of the plant.

This is a perennial grass, 8 to 12 feet high, with thick solid jointed juicy stems. Leaves very long (3 to 4 feet) and 2″ to 3″ wide. Leaf sheaths about a foot long. Lower leaves die down long before the crop is ripe. The inflorescence is a large, graceful, feathery, terminal plume. Some varieties flower regularly, others rarely. The seed or fruit seldom forms.

Habitat.

It is uncertain whether the plant has been found in a wild state in any part of India. It is cultivated through tropical and sub-tropical Asia and the Islands of the Indian and Pacific Ocean and in other tropical parts of the world.

The Bombay area is about 60,000 acres annually. Sátára, Bolgaum, Poona and Násik are the chief centres of cultivation. Distribution in the Bombay Presidency.

The crop is cultivated in almost all parts of the Presidency and on a greater variety of soils than any other irrigated crop. It adapts itself to almost any description of soil if drainage is secured by a pervious sub-soil or by artificial means. A water-logged condition of soil is perfectly fatal to successful cane cultivation. In other respects any description of soil of fair depth suits one or more of the many varieties cultivated throughout the Presidency. Cultivation. Soils, suitable.

The varieties may be broadly grouped into two types, but there are numerous gradations between the two extremes :— Different types.

(A) Thick, juicy, soft kinds which ordinarily require copious irrigation frequently given.

(B) Thin, very hard, less juicy kinds which require lighter irrigation at longer intervals.

On the very light alluvial soils of Ahmedabad and of Bassein and elsewhere on the Thána Coast and on the richer alluvial loams of the garden villages of Kaira, Baroda and Surat, excellent crops of varieties of "A" type are grown. These lands are almost continuously irrigated from wells, and the cane is rotated with other garden crops, such as ginger, turmeric, elephant's foot (*suran*), yams, potatoes, sweet potatoes, groundnut, plaintains and betel-vines. General distribution of the crop in the Presidency.

In the Surat District sugarcane is not confined to soils of the above description only. It is also grown on black soil, slightly tinged with brown, about 4 feet deep, with a deep substratum of yellow earth which consists of an intimate mixture of sand, clay and lime. The sub-soil is fairly pervious to water. Cane is planted in such soil in artificially embanked fields which also grow rice, or on higher drier land; but in either case there is always an interval of several years, usually four to six, between two successive cane crops. Thick soft and thin hard varieties are often grown mixed on such land. It is not clear what advantage there is in growing the two kinds mixed except, when a border of a thin hard variety on the headlands surrounds the soft succulent variety. In this case it is currently believed that less damage is done by jackals and pigs. These pests are supposed to sample the hard cane on the headlands, and, finding it hard or not very sweet, they pass on to a field with a soft succulent variety. Very often the two types are mixed indiscriminately all over the field. The same practices are also common in the Southern Maratha Country. The Surat District has great variety of soil and considerable range in the average rainfall between *tálukas*. It is therefore not surprising that eight distinct varieties of cane should be found in general cultivation, and at least six of these are different Cane in Gujarát.

from any found in the Deccan or the Southern Marátha Country, and two are so distinctively coloured that they cannot be referred to any type found in other parts of the Presidency. These colours in each case can best be described as dirty.

Cane in Southern Marátha Country.

In the Southern Marátha Country cane is grown to a large extent on the favourably situate low lying brown or red-brown laterite soils which also grow rice, and, where good perennial irrigation facilities exist, also grow many other garden crops. On this class of land, also on medium black soil, cane is grown at intervals of three to five years. A cane of peculiar colour is here in common cultivation. It has alternate longitudinal stripes of purple and green. Similar cane is sparingly cultivated in Khándesh and in the Nira valley (Poona District), but not elsewhere in the Presidency as far as I know. In the Southern Marátha Country the general style of sugarcane cultivation is not so advanced as in some districts.

Cane in the neighbourhood of Poona.

The most suitable soil for cane in the neighbourhood of Poona is black or mixed black, got from decomposed trap. It is a stiff clay loam, 2½ to 3½ feet deep, resting on *murum*, which is shaly limestone very pervious to water. This combination of soil and subsoil secures good natural fertility, associated with good natural drainage. Only one variety of cane—"pundia"—is grown near Poona. It is a particularly good variety, and possibly few, if any, other varieties cultivated in other districts surpass or equal *pundia* for the production of *gul* or crude-sugar. The cultivation of *pundia* is rapidly extending in other districts.

Period of growth.

Sugarcane is commonly called a twelve-months' crop. Some varieties ripen earlier than others. A crop which has been heavily manured with a quick acting manure may be forced to maturity in perhaps eleven months, whilst a crop treated with a slow-acting manure may take twelve or thirteen months to ripen. Again, a crop which is repeatedly top dressed with manure continues to grow longer, and probably also yields better than a crop grown with the same amount of manure applied entirely before plantation. Ratoon cane ripens in less time than newly planted cane. In the neighbourhood of Poona cane planted late in March or early in April under canal irrigation is often allowed to stand over two monsoon seasons or for eighteen months. Very often this practice pays, because, although the cane deteriorates, the extra price that *gul* brings (usually 50 per cent. more than in the ordinary season) more than compensates for the loss. The extra charge for canal water is not much, and there are no other extra expenses worth considering.

Seasons of planting.

Cane is planted in different localities at different seasons. In Ahmedabad, Kaira and Baroda, it is planted in May or early in June.

The soil is of sandy character. White ants are very destructive on this class of land, particularly whilst the cane is young. The white ants do not do much harm during the monsoon to sugarcane, because on dry crop areas there is much vegetable growth at this season, which supplies the white ants with food, and the pest being widely distributed over large areas, the damage done is not particularly noticeable; therefore, if the cane is planted in May, it practically escapes damage whilst young. In the Surat District, also in the Southern Marátha Country, most of the cane is planted in November and December, but the season may extend to February. In the Poona District, February and March are considered the best months to plant. The season of planting depends somewhat upon local conditions. Generally speaking, any season is suitable for planting except the hot weather. Young shoots suffer considerably from the hot sun, and a check received at this time from this cause or, in fact, from any cause, is not afterwards recovered.

Propagation and methods of planting.

The crop is propagated from sets, sometimes, as in Gujarát, by planting whole canes. The sets consist of pieces of cane, generally about a foot long. Each set has usually three eye buds, sometimes more, and then the set may be 15″ to 18″ long. When sets are planted, beds are generally previously formed. The sets may be planted at the required distance apart in pits dug out with a small pick and 3 to 4 inches deep. One set is planted in each pit. The pits are in straight rows. The sets when carefully covered with soil are 4 to 6 inches apart in the rows and the rows 2 feet distant from each other. The beds are left level. This practice is common in Baroda. Water is given immediately after planting. Sometimes three or four sets are planted together in a pit, each pit being about 6″ deep and 12″ to 15″ square. The pits are about 2 feet apart from centre to centre. The cane then grows in clumps which stand up well in heavy wind or rain, and which, if bound round by dead leaves, are not easily much damaged by jackals or pigs. The beds in which the clumps stand are left level. In the Southern Marátha Country it is customary, after the field is well prepared and manured, to plough it into ridges and furrows and, after watering, trample in the sets in the furrows. When the soil dries, the harrow or light plough is used to level the ridges over the planted sets and to work the land smooth and friable, so that, when the cane sends up shoots, these may be earthed up with the plough which is worked between the rows, and forms furrows which serve as water channels for temporary irrigation. Subsequently, beds are formed for regular irrigation, but in the case of hard varieties of cane requiring little water, the surface is left level, the rows not being

earthed up, and the irrigation water is led over the field in the best way the cultivator can. This is not a desirable method, but when adopted in order to economize irrigation water as much as possible, grass is spread over the surface, and a fine layer of earth is put on the grass. This conserves moisture, and therefore fewer waterings are required. In the Dhárwár District the following is a common method of planting. Cane sets are put in furrows which are made by the plough. The sets are placed 3″ to 6″ apart, and are 12″ to 15″ long. Planting is done in February. The field is immediately watered. It is not laid out in beds at all. About a handful of manure is put over each set at the time of planting. When the soil dries after the first watering, the ridges are split with the plough. This is done before young shoots spring up. The sets now occupy the ridges, and the furrows serve as water channels for irrigating the crop, and extend along the least slope, generally either the whole length or breadth of the field.

When whole canes are planted, a heavy plough is used. The canes are passed through a hole drilled in a slanting or inclined backward direction through the body of the plough, and are left imbedded in the soil in the furrow and about 6 inches deep. This operation is facilitated by a man following the plough and trampling each cane into the furrow as it is pushed through the hole in the plough. The seed rate is calculated in lengths of 6 *háths* (about 9 feet); about 2,500 6-*háth* lengths are planted per acre. Very few single canes are each 6 *háths* long. This method of planting is of doubtful advantage for various reasons. It is slow. The cultivators of the districts, where this method is practised, think it is most expeditious; but this conclusion is wrong. Many of the eye buds are destroyed in passing the cane through the plough. Planting is commonly done in this way on black soils in the Surat District. If the plough is carefully guided, the rows are moderately straight, and are about 20 to 24 inches apart. After planting, the surface is smoothed and made into temporary shallow beds, and enough water is given literally to swamp the field. As soon as the soil dries, the light plough is worked to stir the surface soil to a depth of about 3 inches. The sets are planted below this level, and are not disturbed by the light plough. This light ploughing may be done twice. It kills weeds, and leaves the surface soil loose and friable, so that when the rows of young shoots are well up, they can be earthed up, and beds can be easily formed in the ordinary way for regular irrigation. The second watering is not given for six weeks or two months after plantation, and generally not more than twelve to fifteen waterings are given during the year and in artificially embanked land only nine. Deep black soil

is, of course, very retentive of moisture, and the cane, being planted deep, is favourably placed for moisture ; still the practice of withholding water for a period of two months after plantation is by no means common. It is generally conceded that at least the soft succulent varieties of sugarcane on almost any class of land, if grown from sets, require frequent light irrigation until the young shoots are well up.

Deep planting advantageous.

There is no doubt that there is considerable advantage in planting cane deep, except on very retentive soil. If planted deep, the roots get a firm hold of the soil, and the canes are more or less supported, so that a heavy crop is not likely to be lodged by rain or wind. If planted deep in dense heavy soil, germination is interfered with ; at least cane will not germinate evenly if planted in this way on such land.

The Mauritius system of planting.

The Mauritius system of planting is, I believe, advantageous on any description of moderately free working soil. In this system pits, a foot, sometimes more, in depth, are dug about a yard apart in each direction. 2, 3 or 4 sets are planted in each pit and covered carefully. If the pits are deep they should not be filled up level with the surface until the young shoots appear above ground. Beds are formed for irrigation. Recently introduced Mauritius varieties do well when planted in this way, and it is probable that such Indian varieties as freely tiller would also succeed ; but experimental trials are necessary.

Cane usually grown at intervals of several years.

In most districts of the Presidency sugarcane is rarely grown on the same land at shorter intervals than four to six years. Nowhere, except in the Poona District, is cane grown continuously for several years, and in no other district is ratooning practised to any appreciable extent.

Ratoon cane.

A ratoon crop is one grown from the root stocks of the previous crop. There is clear evidence from the experiments at Mánjri that it is risky in the Poona District to take more than one ratoon crop. If new cane is planted on clean land, as of course it ought to be, there is little difficulty in keeping the new cane free of weeds particularly if the crop is heavy. It is not so easy to keep the succeeding ratoon crop quite clean. In the third year it is well nigh impossible, however careful the tillage may be, to prevent *hariáli* (*Cynodon dactylon*) and other grasses and weeds becoming more or less established. The young shoots of the second year's ratoon come up weaker than those of the first year. The root stocks of the former get overgrown to the extent that the distribution of irrigation water is interfered with.

Throughout the Poona District two successive ratoon crops are generally taken. The first ratoon crop gets generally a lighter dressing of manure than new cane, and the second ratoon crop gets a much lighter dressing, sometimes none at all. It is quite likely that residues of heavy dressings given to new cane and the first year's ratoon would suffice for the second ratoon crop without any direct application. Ratoon cane grown in this way would probably pay, even though a poor crop, because the cost of manure is by far the heaviest item in the cost of cultivation. On the other hand, deep-rooted grasses and other weeds might get thoroughly established. The cost of cleaning and fallowing would be heavy. The profit from first ratoon is greater than from new cane. The preparatory tillage for the former is trifling. There is no expenditure for sets or for planting. Less irrigation and less manure is required.

I tabulate below outturn, &c., results from first and second year's ratoon grown on comparative plots at Mánjri (Poona). The plots were equally manured to secure fair comparison. Rather heavy dressings of manure were given. In ordinary practice less manure would probably have been given to the first year's ratoon and certainly to the second year's crop.

First Year's Ratoon.

Manure.	Weight of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Outturn of *Gul* per Acre.	Cost of Cultivation per Acre.	Value of Produce per Acre.
	Tons.	Lbs.	Lbs.	Rs. a. p.	Rs. a. p.
Safflower and groundnut cake	3·3	68,030	7,680	320 10 0	426 10 0
Poudrette	22·65	73,580	8,055	324 14 0	447 8 0

Second Year's Ratoon.

Safflower and groundnut cake	3·3	38,510	4,095	292 4 0	227 8 0
Poudrette	22·65	34,530	4,040	301 14 0	224 7 0

Possibly, if a much lighter dressing of manure had been given to the second year's ratoon as in ordinary practice, the crop would have paid fairly well.

Cane is grown almost continuously under canal irrigation in the Poona District. Occasionally the land is fallowed and rested for a few months, and, when thoroughly clean, a green manure crop of *san* (*Crotalaria juncia*) is grown and ploughed in. This crop is every-

where recognized as a good preparation for sugarcane. A green manure crop of *kulthi* (*Dolichos uniflorus*) is also considered in the Deccan a good preparation. Groundnut before sugarcane is considered good practice if the groundnut is well manured. The cultivation of sugarcane in the neighbourhood of Poona is perhaps typical of what it should be elsewhere, and may therefore be fully described. The best soil is a clay loam, and the best preparatory crop is a green manure crop of *san*. The *san* should be sown thickly in June or July (about 70 lbs. seed per acre), and ploughed in when 3½ to 4 feet high. The crop, if thick, smothers surface weeds. It enriches the surface soil with a mass of organic matter which quickly decays, and therefore leaves the soil open and friable, so that subsequent tillage operations can be done quickly and well. If no green manure crop has been grown, the land is allowed to lie waste during the monsoon. This is objectionable, because grasses and other weeds get established, and subsequent tillage and cleaning operations are expensive. The field is deeply ploughed in November with a large eight-bullock plough, an acre being covered in about four days. The soil is turned up into huge clods, and is allowed to weather before it is cross-ploughed. One or two subsequent ploughings in December improve the tilth considerably. Most of the clods break up into smaller nodular pieces, and the soil becomes easily moved to a depth of about 10 inches. I may note that I have been able to accomplish the ploughing operations for sugarcane with Ransome's Turn Wrest plough quite as effectively as with the best pattern of indigenous plough and at considerably less cost for manual and bullock power. I advocate the use of the Turn Wrest plough for sugarcane and other garden crop cultivation; but for ordinary dry crop cultivation I cannot conscientiously urge that this plough or any other iron turn-furrow plough is as good as the best indigenous implements. After thorough ploughing the surface is levelled with a log harrow, and clods are broken, if necessary, by hand with a mallet or thick short stick. Then manure is applied. Poudrette or farm yard manure is most commonly used in the Poona neighbourhood, 60 loads, or, say, 30 tons, of either per acre being the usual dressing. If so much is given before plantation, the crop gets no top dressing afterwards; but usually a smaller application of poudrette or farm yard manure is given before plantation, and the crop is top dressed in June or July with castor cake, *karanj* cake, fish manure or other concentrated manures.

Cultivation in the Poona District.

It has been proved by the Mánjri experiments, which will be referred to in detail further on, that certain manures are more active and effective for sugarcane than others, and that apparently the most important

Nitrogen in immediately available form necessary for cane in the early stages of growth.

constituent of manures for sugarcane is nitrogen in immediately available condition. The experiments clearly indicated, if they did not absolutely prove, that nitrogen in this form was absolutely essential to feed the young shoots during the early stages of growth. The sugarcane set itself contains very little on which the young shoot can feed. Therefore, in the case of land in low condition the manures to be applied before plantation should be such as are known to be quick-acting, as, for instance, poudrette, fish manure and the various country-made oil cakes. Farm yard manure, which has the reputation of acting slowly if used, should be thoroughly decayed before application. In this condition it will probably act more effectively and quickly.

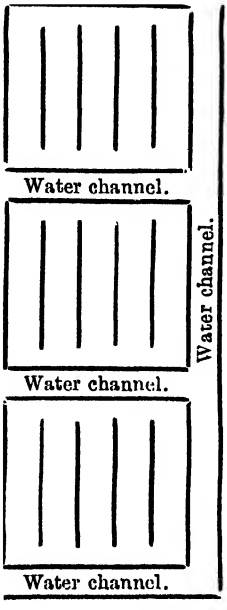
What is the most economical dressing of manure for cane.

It has yet to be proved what is the most economical dressing of nitrogen that should be given to produce the best results. Dr. Leather has shown by analysis that even a heavy crop of sugarcane does not take up more than 100 lbs. of nitrogen per acre, yet if all the manure is applied before plantation, as it ordinarily is in common practice, at least 400 lbs. of nitrogen per acre must necessarily be given for the best results. To provide this quantity of nitrogen, probably about 30 tons per acre of ordinary cowdung and compost manure would be required. If this application contains the required quantity of nitrogen, it will certainly contain sufficient of other important elements of nutrition.

Top dressing recommended.

There can be little doubt that the copious irrigation necessary for sugarcane washes manure away in the drainage. Dr. Leather has proved by analysis that during the process of the manurial experiments at Mánjri the soil has accumulated fertility, and that manures not removed by the crops are still to a large extent in the soil. There was evidence of this in 1897. The whole comparative manure area was rested for a season, and on all the plots as well as on the pathways between plots a catch crop of green fodder was grown. On almost all plots the growth was very luxuriant, and the exact limits of each plot could be seen at a glance. The pathways between the plots grew in every instance only a middling crop. These pathways received practically the same tillage as the plots during the previous three years, but got no manure. The mere fact that so much nitrogen is given in the manure and so little is taken up by the crop suggests the idea that it would be far more economical to apply a smaller dressing of manure in repeated top dressings. This is practicable as regards concentrated manures like oil cakes, but is hardly practicable in the case of bulky manures like farm yard manure and poudrette, &c., because of the difficulty of spreading evenly a bulky manure on a crop

which has grown so that it completely shades the ground. The whole question requires thorough elucidation by experiment.



Method of applying manure and subsequent tillage.

Poudrette or farm yard manure should be deposited in heaps regularly over the field, three or four heaps from one cart load. The manure should be evenly and carefully spread. The land should now be ridged up with the plough into ridges 24 to 28 inches apart, the furrows being as deep as possible. The plough should then be run across the line of ridges to form parallel water channels 10 feet apart. Finally, the field should be laid out into beds 10 feet square. The *bándh* round each water compartment should be raised by soil moved with the hand hoe from the furrows and by removing about 9 inches from the ends of each ridge inside any particular water compartment. Each compartment when complete contains four short ridges and five furrows, as shown in the marginal diagram. The thick lines indicate the crests of the ridges.

Planting.

The planting operation proceeds very methodically. One acre of good cane provides sets sufficient for eleven or twelve acres. Ratoon cane usually provides the best sets, because the joints or nodes are close together. Usually the sets got from the top end of the cane are longer than those from the base, because the nodes of the former are farthest apart. That portion of the cane nearest the green top is considered suitable for planting. Some authorities consider the "tops" better for sets than any portion of the mature cane. There is no doubt that the tops when used as sets root quickly, and the central shoot springs into growth very quickly, and the germination is therefore very regular and satisfactory; but it has yet to be proved whether the resulting crop is better or worse than from ordinary sets planted in the ordinary way. Each set from the top end would be quite a foot long, whereas from ratoon cane the sets would not be more than 8 inches long on an average. 16,000 to 18,000 sets are required per acre in the Poona District. The sets are carried in head loads to the field to be planted and laid along the ridges and on the *bándhs* of each water compartment. Water is turned into each bed in turn. When the water has partially soaked into the soil and softened it, the planter begins to lay the sets carefully in the bottom of the furrows, trampling each set down 3 or 4 inches into the soft mud. The distance between sets is

about 4 inches. Planting in the Poona District should be done, if possible, in February, and certainly finished before the middle of March.

Application of concentrated manure.

If a concentrated manure is used, it should be applied after the beds are formed and before the sets are planted. It should be broadcasted by hand along the furrows and mixed with the soil by stirring lightly with a small pick or hand hoe.

Weeding.

A month after planting, the land should be carefully weeded with a *khurpa* or hand-spud. This tool is like a small sickle, both the outer and inner sides are ground or bevelled, so that there are two cutting edges. The weeding should be repeated as often as it is necessary. Usually four weedings are required. The *khurpa* is used not only to remove weeds, but to move the surface soil. This is beneficial as the soil cakes on the surface after irrigation.

Making new beds in June or July.

In June or July new beds are formed. The soil is dug and levelled, and all weeds removed. A second dressing of manure may now be conveniently given. The canes originally planted in the furrows are earthed up with a hand hoe. This leaves a furrow between the rows of cane. These furrows serve as water courses for water, admitted into each water compartment. The earthing up gives support to the cane, so that it does not readily lodge even if a very heavy crop.

Lodging of cane causes loss of sugar. How to prevent lodging.

Lodging is harmful, inasmuch as Dr. Leather has proved by analysis, that lodged cane contains a smaller percentage of crystallizable sugar than upright cane. A sprinkling of *shevri* (*Sesbania ægyptiaca*) or of castors in the crop and particularly along the water channels and borders gives support to the cane, so that it does not readily lodge. Moreover, the *shevri* and castors yield good returns. Both plants grow to a height of some 15 to 20 feet in a year. The young *shevri* branches are pruned and sold as fodder for milk-goats, and the trees give poles useful for roofing huts. The value of the produce from castors is also considerable. Sometimes, to prevent lodging, cane is tied up. This operation must be carefully done to be effective. Canes from different roots should be tied, about six canes together loosely, but securely, with a band of dead leaves about 4 feet from the ground.

Trashing and wrapping.

Cane is trashed by removing all dead side leaves; thus air gets freer access, and, no doubt, the crop is benefited. Wrapping the cane in its own dry side leaves is a costly operation which, however, probably pays where jackals and rats are very destructive. Jackals will not do much harm to wrapped cane if there is unwrapped cane conveniently near.

Irrigation and amount of water actually given for cane in Poona District.

After July or August in the Poona District cane requires no further attention except watching and careful watering. Irregular irrigation spoils the quality of the crop. It causes in soft juicy varieties splitting of the cane. The land is first flooded as the sets are planted and thereafter two or three times at short intervals to encourage the eyes to shoot. Subsequently, eight to ten days may elapse between waterings; the shorter interval in the hot weather, the longer in the cold season. During breaks in the rains irrigation is required. The rainfall in the Poona District averages about 30 inches. I have found by actual measurement that sugarcane on an average gets during twelve months, in addition to the rainfall, irrigation water equal to 75 to 80 inches of rainfall, the crop being irrigated on an average 28 times in a year. Therefore, the water given at each application was equivalent to $2\frac{1}{2}$ to 3 inches of rainfall or, approximately, 250 to 300 tons per acre. This is the quantity of water taken by an ordinary cultivator when he supplies himself from the canal. He would use less, probably to the advantage of his crop, if he drew the water from a well. We proved by actual experiment that more frequent lighter irrigation was preferable, *i.e.*, that a considerably heavier crop was got by irrigating 34 times during the year, giving in all water equivalent to 50 inches of rainfall in addition to the rainfall (30 inches). The extent of irrigation necessarily depends upon various circumstances. The thin hard bamboo varieties require much less water than the soft thick succulent kinds. In deep moisture holding black or clay soils the interval between waterings in the fair season may be much longer than on soils of lighter description. In the sandy and light loam soils of Northern Gujarát, irrigation for soft cane is necessary every fifth or sixth in the hot weather and every seventh or eighth day in the cold weather. In contrast to this it may be noted that soft varieties, grown in the Surat District on embanked rice fields with deep soil retentive of moisture, if planted deep with a plough in moist soil in November, do not need water until the following February. Cane planted after November requires to be watered in January to assist germination. Six waterings are given between February and the end of May. No artificial irrigation is required in the monsoon, but two or three waterings may be given after the rains in September-October.

Subordinate crops.

Sugarcane makes slow growth during the first three months, and it is quite common to grow with it subordinate crops which ripen quickly. Maize, *guvár* (*Cyamopsis psoraliodes*), onions, cucumbers, melons and tobacco are so grown. The maize cobs are plucked before being ripe, and used as a green vegetable. The stalks are cut green, and therefore give much better fodder than that from a dead

ripe crop. The *guvár* beans are also plucked green whilst the uprooted stalks are broken up by hand, and with the leaves are left on the ground to serve as a green manure. Onions are grown from transplanted seedlings raised in a separate seed bed. They may reach maturity before the sugarcane quite shades the ground. If they do not, it does not matter as they are quite marketable at almost any stage of growth. Melons and cucumbers are grown from seed planted here and there, but more particularly on the headlands. These plants make very rapid growth in a heavily manured sugarcane field. Tobacco is planted along the water courses and on the *bándhs* of the water compartments, and takes about five months to come to maturity after the seedlings are transplanted. If the sugarcane, meantime, makes rapid progress, the tobacco will not come to much.

Diseases of Sugarcane.

White ants destructive. Castor-cake as a preventative.

On sandy or light soil white ants are often very destructive. They attack the sets, the roots and the stems. Castor cake used as manure is believed to keep white ants away. In Gujarát a common practice is to put a quantity of pounded castor cake in a reservoir near a well. The irrigation water is made to flow through this reservoir. The cake gets soft and pulpy, and an extract is carried by the irrigation water to the crop. In a few days the manurial value of the cake becomes exhausted, and the spent cake is removed and thrown in the common manure pit. It is quite probable that this is an effective method of using castor cake or perhaps any other cake as manure, and the extract has fully as much effect in keeping white ants away as cake directly applied. It is questionable whether the cake becomes really exhausted by a few days' steeping, yet it may be so, for a somewhat analogous effect is well known by gardeners, *viz.*, that if fresh cowdung or horse dung is steeped in water for several days, a liquid manure is produced which is extremely effective for roses and other plants in pots.

Salt for white ants.

Salt is also used as a preventive for white ants. The method of application is simple. It is tied in a cloth or sack mixed with assafœtida and hung at the head of the water channel, and gradually gets dissolved in flowing water.

Aphides on sugarcane.

Sugarcane is subject to several blights, known by various vernacular names, but all due to aphides which increase rapidly, especially in cloudy weather. Their presence is always accompanied by sticky matter on the leaves. These insects feed on the juices of the plant, and thus exhaust the vigour of the cane. Insecticide spray applications are the only effective remedies. An easily prepared insecticide application would consist of 2 lbs. soap boiled in one gallon of water;

add 2 gallons kerosine; churn or agitate the mixture until an emulsion forms; dilute with 15 to 25 gallons of water, and apply to the affected foliage with a spraying machine.

A species of scale insect is common, and, when it exists to any extent, does considerable harm. An observant cultivator will detect the pest early. All affected leaves should be removed and burnt, and the pest is thus at once checked. Scale insect.

The sugar borer, *Diatræa saccharalis* (vern. *Gabra*) often does an immense amount of harm, and yet damage by this insect can be very easily checked, if proper measures are taken in time. The pest usually makes its appearance when the cane has fairly germinated, and the first indication, in the young shoots, is the withering of the uppermost central leaves. The middle or leading shoot can be easily pulled out from its envelope of leaves, and the core of the stalk is found quite rotten with an offensive smell. A number of small white grubs are always present, and in large numbers if there is much rottenness. These are not the cause of disease, but harmless larvæ of small black or brownish flies which follow the borer. The true cause of the mischief, the larvæ of the sugar borer, is seldom found. The round hole by which it entered may be seen, but when there is much rottenness at the core, the borer has probably gone to another cane. If, when the first sign of withering is seen, the affected cane or shoot is cut close to the ground and slit up, one or more borers will be found in a tunnel made in the solid cane. Professor T. H. Middleton, late of Baroda College, describes the sugar borer thus:— Sugar borer.

"The full grown caterpillar is about $\frac{4}{5}$" long and $\frac{1}{4}$" diameter. The body is yellowish white with purple lines along the back. The head in the young is almost black, is brown in half grown, and light brown in full grown specimens. The sides of the body segments and the tail are furnished with short side-bristles. Young and half grown specimens are very active, but the old caterpillars are slow in their movements. The pupa is about $\frac{1}{2}$" long, is blunted and of brownish colour at the anterior end, pointed and golden yellow at the posterior. The moth emerges from the pupa after seven days. It is grey coloured $\frac{3}{4}$" long with $\frac{1}{4}$" spread of wings. The first pair of wings is grey with fringed margins and black spots just inside the margin. The second pair is silvery. The abdomen is plump silver grey, and extends $\frac{1}{4}$" beyond the wings. The moth is very sluggish in captivity, and there is reason to believe that it does not move far from one locality when free."

Cut close to the ground, and burn all affected shoots *as soon as* withering of the central leaves is noticed. The caterpillars are almost certain to be inside the cane at this time. If no remedial treatment is adopted, the insects will run through many generations in a single season, and the crop will be greatly damaged; not only so, but the canes will be so infected that they cannot be safely used Remedies for sugar borer.

for sets for re-planting. The sugar borer also attacks *jowár* and maize, but the moth is so sluggish in its movements that a field cleared of the pest as described above is not likely to be re-infected by insects coming from a distance.

A root parasite.

Sugarcane, like *jowár* and some other cereals, is subject to attack by a vegetable or root parasite, *Striga lutea* (*Tavli*, Deccan; *Ágio*, Gujarát). The *Ágio* of Gujarát appears to have fleshier leaves and stems than the *Tavli* of the Deccan, but they are clearly botanically very much the same, if not identical. The parasite is found thriving close to the stems of cane, or of *jowár*. Its fibrous roots entwine round the roots of the crops named, and check their growth. The parasite grows rapidly, and the only way to save the crop is by constant weeding. *Ágio* belongs to the natural order *Scrophularineæ*. It is found abundantly in grass *kurans* (pasture lands), and therefrom doubtless finds its way to arable land in the dung of animals. It survives without a host; but it can be carried in the host plant. In proof of this, I noticed one particular variety of cane, on the Surat Farm in 1897, badly affected at an early stage of growth. Other varieties in other adjacent beds were not affected. If once established in highly manured sugarcane land, it thrives amazingly. In irrigated land it flowers and seeds at all seasons, and is, therefore, extremely difficult to eradicate.

Smut.

Sugarcane is subject to smut which is probably caused by the same species of *ustilago* as causes the smut, so common in ordinary cereals. Apparently the disease only attacks the flowering rachis, and if it is really confined to these parts, it cannot do much damage to the crop, as sugarcane does not commonly produce flowers. It is unusual to find varieties, which have long been grown in India producing flowers; but varieties of vigourous habit of growth, which have recently been introduced into India, generally flower freely. I have only observed smut in thin hard or bamboo varieties, and its effect is most curious. At the Poona Farm cane propagated from sets became affected with smut when three months planted. The affected flowering stalks were premature growths. In the ordinary course no inflorescence would have been produced for ten to twelve months after plantation. The presence of disease spores apparently forced the premature growth of the inflorescence in order to provide a suitable host for the disease. The source of infection was obscure; the crop from which the cane sets were got had not been observed to have been affected. Sets from this variety, as well as sets from many other varieties, all grown at Poona were sent to the Surat Farm, and also planted at Poona. At both farms this particular variety and no other variety became affected. It

might be urged that the sets, or their eye buds, were obviously the source of contagion. The practice of pickling cane sets in the same way as seed grain, as a preventative is obviously inapplicable; and the only remedy appears to be to remove and burn all affected shoots.

Harvesting.

Tests of ripeness.

It is difficult to judge accurately by the eye when sugarcane is ripe. Frequently a cane grower tests the ripeness of his crop by a trial boiling. If so many measures of juice give a satisfactory weight of *gul*, harvesting operations are proceeded with, otherwise the work is postponed for a fortnight or longer. A cane crop usually gets a yellow appearance as it ripens, but this colour may also be caused by irregular or deficient irrigation; and a crop that is in want of manure, or is otherwise badly cultivated, gets yellow long before it is ripe. In a well grown crop, if the side leaves are all dead, and if the eye buds almost to the top of the cane are fully developed and firm, the cane is probably quite ripe. I do not think any loss is occasioned if the crop is allowed to stand for a short time after it is dead ripe, provided (*a*) it is not lodged, (*b*) that the eye buds have not begun to freely grow, (*c*) that irrigation is regularly given. If the cane is watered a few days before it is harvested, the amount of sap is increased, so that more juice is expressed by the mill, and, therefore, more sugar obtained.

Reaping.

Method of harvesting.

If it is intended to grow a ratoon crop, the cane should be cut with a sharp sickle at a height of 1 to 2 inches above ground. If no ratoon crop is to be taken, the cane should be uprooted, each cane being separately removed from the root stock by a sharp jerk. Uprooting is easily done as the roots have not a firm hold of the soil. Cane should be reaped, or uprooted, in the early morning whilst the leaves are yet wet with dew. Later in the day, the heads and arms of the workmen would be cut by the sharp edges of the dry leaves. A second man follows each reaper, and with a sickle strips the dry side leaves from each cane. With practice any ordinary cooly can acquire the knack of doing this expeditiously. The upper green leaves, which are useful as fodder, are not removed in the field. The dry side leaves are left as a litter over the surface of the field. Subsequently, they are collected, and tied into huge head loads, and carried to the *gurhál* to be used as fuel in the *gul* boiling process, or as thatch for huts, &c. The cane is tied into bundles, and carried in head loads to the *gurhál*, or if the distance is far, in carts.

Harvesting and *gul* making done by contract.

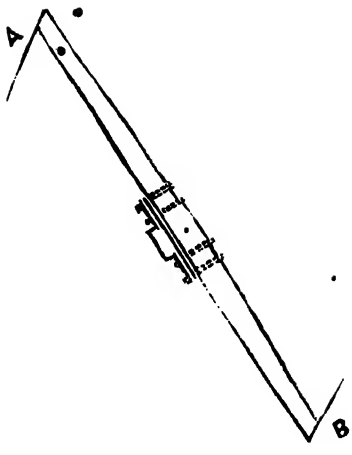
The whole operation of harvesting and *gul* making is undertaken in the Poona District at contract rates. The owner of the field supplies a cane crushing mill or mills, and all *gul* making apparatus, and also lubricating oil. The contracting workmen find four pairs of work cattle for each mill. The cattle are worked in relays, two pairs at a time. Eleven workmen are attached to each mill. Unless each man has an interest in the contract, more are required. They cut and carry cane sufficient to give juice for four boilings in a working day (the work being partly done at night). Each boiling requires 22 *gharas* (earthen pots) of juice. The juice required to fill a *ghara* weighs approximately 42 lbs. One boiling of 22 *gharas* produces one *dhep* or sugar loaf of crude sugar (*gul*), and each *dhep* from the Poona *pundia* variety of cane weighs from 148 to 160 lbs. according to the quality of the juice and the luxuriance of the crop. The contract rate for four *dheps* per day is, generally, Rs. 5. Sometimes it is as low as Rs. 4. The contracting workmen get as much cane for raw eating as they like. Their women and children surreptitiously take, or at any rate get, a good deal, and every passing wandering beggar expects a good big piece of cane. The contracting workmen get the green tops to feed their cattle. Ordinarily a good many more cattle than the work cattle are actually fed. The extras, *i.e.*, the cane for raw eating, and the green tops for cattle feeding, vary in value in different seasons. Therefore the contract rate also varies.

Crushing.

CRUSHING.

The Poona pattern of cane mill.

The most approved pattern of mill in use in the Bombay Presidency is a three iron roller mill made by several firms in Poona. The mill is made in various sizes. The most common pattern costs Rs. 120, and has three rollers (height of rollers 18″, diameter 11″) ranged vertically between upper and lower cast-iron plates. The two side rollers revolve in sockets, placed on the upper and lower plates. The upper part of each roller is cut like a cog wheel. The cogs of the two side rollers work into those of the middle roller. The draught bar is attached to the central roller, and this roller communicates motion to the two outside rollers. The rollers are adjusted, in respect of closeness to each other, by long iron wedges, which, when driven home at the upper and lower sockets, move the side rollers closer to the central roller. The shaft of the central roller passes through the upper plate. It is round in shape to a height of 6 inches or so above the plate. The rest of its length is square. On the upper square end of the shaft a rest for the draught pole is securely keyed. The draught pole is bolted to this rest.



The draught pole has sometimes at its centre an iron piece fashioned as per marginal drawing. This iron piece is keyed to the squared part of the shaft of the central roller, so that the central roller gets direct motion from the draught pole, as it is turned by a pair of bullocks, attached at A, and another pair attached at B. When the mill is adjusted for work, the rollers should be perfectly vertical and so close together that it is hardly possible to see through between two adjacent rollers.

Cane crushing.

The cane is passed twice through the mill, first between the middle and one outside roller and back between the middle and the other outside roller. These operations go on simultaneously, two men, one on either side of the rollers, being required, one feeding the whole cane, the other feeding the half crushed cane. The draught pole is fixed on the shaft high enough to pass over the heads of these men as they sit in the usual native position at work. Two men or boys drive the work cattle, and it is the duty of one or other of these to remove the crushed refuse as it collects, a basketful at a time, and throw it down evenly in an open space to dry, so that it can subsequently be used as fuel in the boiling process. A man prepares the canes for the mill by removing the green tops and cutting long canes into two shorter lengths for more convenient handling by the man that feeds the mill. Three or four pieces of canes are passed between the rollers simultaneously. Iron mills of the above pattern can, when properly adjusted, express up to 73 per cent. of juice from soft succulent varieties of cane. The quantity of juice expressed in a working day is approximately 3,700 lbs. If the cane is soft and succulent, the working day is short, but long if the cane is hard and less juicy. The edge of the lower plate is turned up about 1½ inch in the shape of a rim. The juice, as it is expressed, collects here, and flows through an opening into a receiver placed under ground. This receiver holds eleven *gharas*, so that it has to be twice emptied to supply juice sufficient for one boiling. The bottom plate of the mill and the top of the underground receiver are practically level with the ground. Close fitting loose boards are placed over the receiver. The man who feeds the half crushed cane sits on these boards and notices that the receiver does not overflow with juice. The juice

from the underground receiver is emptied into two iron drums placed near the evaporating pans. It should be strained through cloth or through a wire gauze sieve to remove impurities. When these drums are quite full, the juice is emptied into the evaporating pan. The two drums just hold enough (920 lbs.) juice for one boiling.

The old fashioned wooden mill.

Iron mills have taken the place of wooden mills in all parts of the Presidency. In Gujarát and in Dhárwár only a few of the cane cultivators own iron mills. The use of these will extend as the advantages become known. Their advantages, both as regards economy in labour and effectiveness at work, cannot be questioned; still the old wooden mill is very much in evidence. A common belief prevails that the wooden mill gives purer juice which can be made into finer *gul* than the iron mill; but this is mere fancy. The true reason why the wooden mill keeps in favour is that it is made locally, and the parts can be replaced or repaired as they go wrong. The mill costs Rs. 35 to 50. It is slow at work and constantly liable to accident, causing suspension of operations until the village carpenter arrives to repair it. The iron mill is an adaptation of the wooden mill. The latter has three wooden rollers about 3½ feet in length and 1 to 1½ foot in diameter. These are placed side by side in a strong wooden frame. The upper part of each cylinder is cut out in the form of a screw. The draught bar is attached to the central roller, much in the same way as described for the iron mill. The middle roller is called the husband and the side rollers the wives. The male screw of the central roller fits into the female screws of the side rollers, and communicates motion to the side rollers. The cane has to be repeatedly passed between the rollers before all the juice is expressed. The mill, though clumsy and heavy to work, extracts the juice fairly well. A wooden mill in good working order extracts as much as 56 to 60 per cent. juice from soft succulent cane.

***Gul* making.**

The evaporating pan in most general use is about 7 feet in diameter and 9 inches to 12 inches deep. It is made of stout sheet iron which in pieces of the required shape are riveted together. The pan has four circular handles each about 4 inches in diameter, welded or fixed to the lip of the pan at equal distances apart. When it is necessary to place the pan on the furnace or remove it therefrom, two stout poles are passed each through a pair of opposite handles. Four or more men lift the pan and carry it steadily by means of these poles. Two pans are required—one is used for evaporating, the other as a cooler into which the hot *gul* is emptied when boiling is complete.

The boiling process.

The oven or furnace is of simple construction. A trench is dug about 18 inches wide, 8 feet long, gradually getting deeper towards

one end until a depth of some 5 feet is dug out. A circular excavation is now made at the deep end with a diameter of 4 to 5 feet. This circular chamber and the trench is the source whence the oven or furnace is provided with a draught of air and also provides room for the ashes. The ashes which collect one day are removed before work begins the following day. The furnace which is partly excavated and partly built up is of larger diameter than the ash chamber. It is nearly the same diameter as the evaporating pan, being about 6 inches less, so that the evaporating pan fits neatly on the top of the furnace. The ash chamber being of smaller diameter than the furnace, a ledge is left between the two on which corrugated iron sheets are laid to form the bottom of the furnace. There is a grating in the centre about a foot square. Ashes escape through this, and the draught air is admitted. The furnace is built up with sun-dried bricks in a circular form inside to a height of about $3\frac{1}{2}$ or 4 feet. The brick-work is banked up all round with earth. The front is built up square, and a small opening is left, about 20 inches × 14 inches, through which the fire is fed with fuel as required. The lip of the oven is plastered smooth, so that the evaporating pan fits accurately. The furnace is of large dimensions, because it is necessary to maintain a regular moderate heat during the boiling process.

Preparing the pan.

The pan is prepared before use by rubbing it well inside with leaves of the castor oil plant and then with a paste of *udid* (*Phaseolus radiatus*) flour and *til* (*Sesamum indicum*) oil, the object being to prevent the *gul* burning and sticking to the pan. The *udid* flour preserves the oil, so that the pan only requires re-coating occasionally. It is not required oftener than every two or three days.

Professional boilers.

The sugar boilers are professionals in the Poona District, and pretend that special knowledge is required to make good *gul*. There is no mystery in the art further than that a regular heat should be maintained and that all impurities should be skimmed off during boiling.

Fuel.

The dry side leaves and the dry refuse of crushed cane usually provide sufficient fuel, especially so in the case of a good crop. If extra fuel is required, the husk of safflower or the stalks of *tur* (*Cajanus indicus*) or of cotton or light brush wood are commonly used.

Feeding the fire.

The fuel should be of such kind that the fire can be continuously fed by small quantities thrown into the furnace at a time.

Skimming.

As soon as the juice begins to boil, impurities rise to the surface in the form of a scum. This should be removed. Skimming is done with a long handled wicker work ladle which allows the pure juice to drain away, but retains the thick scum. This ladle is also used to agitate the syrup vigorously, to prevent boiling over when the fire is too hasty.

Impurities removed.

The impurities are most effectively removed if a mucilagenous extract from the *bhendi* (*hibiscus esculentus*) plant is mixed with the juice when boiling begins or at a later stage.

The boiling process.

It usually takes about 2½ hours to boil a panful of juice to the proper consistence. When evaporation is nearly complete, the mass acquires the yellow brown colour of *gul*. It heaves and bubbles rather than boils, and should be kept in constant movement by a wooden hoe moved backwards and forwards in all directions. The syrup is boiled sufficiently when a little put in cold water hardens quickly. The pan is then removed from the furnace. A blessing is invoked, and the contents emptied into the cooling pan. Here the *gul* is stirred repeatedly with a wooden hoe as it cools. When it is cool enough, it is put before it hardens by means of a wooden spatula into a cloth which lines a cylindrical hole in the ground. Here it sets into a hard block or *dhep*. It is removed next day and is ready for sale. If the blocks are pale in colour and hard, the *gul* is considered of good quality.

Comparative trial with different mills.

In 1898 a comparative trial was arranged for in the Dhárwár District by the Agricultural Department to demonstrate the capabilities of the Poona three-roller iron mill, in comparison with the time honoured wooden mill and with a double squeeze three-roller iron mill made at Bellary (Madras), which has recently come more or less into use in the Dhárwár District. The opportunity was also taken to demonstrate the Poona method of sugar boiling.

I believe that successful demonstrations of this kind are impressed much more forcibly and beneficially on the minds of ordinary agriculturists if conducted by native officers, provided the men so employed have tact, shrewdness, and thorough practical knowledge of the work in hand. The overseer of the stock farm and sugarcane experiments at Mánjri, who is a *Kunbi* or agriculturist by caste, was sent to conduct the trial. With him was also sent a professional sugar boiler of the Poona District, also a man accustomed in the Poona District to feed fuel to the fire during the boiling process. These men could, with their own hands, build a fire place and other necessary construction of a *gurhál* according to the Poona plan. The work referred to and the boiling process require a certain degree of expertness which is very easy to demonstrate by actual practice, but which would be difficult to describe by tongue or pen.

A three-roller mill and all the apparatus necessary for a complete outfit for sugar boiling were sent to Hirekerur, Dhárwár District. The cultivation of sugarcane is very extensive in this place. The apparatus had been in use for two seasons at Mánjri, and the success of the trial may fairly be gauged by the fact that cane cultivators offered

to buy the mill and all the apparatus at cost price. In consultation with the Collector, it was decided not to press for freight charges from Poona, because, with the exception of the mill (the freight charges on which would be trifling), the rest of the apparatus can be locally made, now that a proper pattern is available. The freight charges on all the apparatus amounted to Rs. 70, whilst those on the mill only would be under Rs. 20.

The tabulated statements which are given below show that the Poona mill, doing three-fourths of the work in a day, which it ordinarily does in the Poona District, is not only a labour saving machine as compared with the Bellary mill and the old fashioned wooden mill, but at work is considerably more effective. The amount of juice left unexpressed by the Bellary mill which the Poona mill could have expressed represents a loss of one pound of *gul* per every 100 lbs. of cane crushed, and in the case of the wooden mill 2½ lbs. of *gul* per 100 lbs. of cane. Forty tons per acre of cane is not a heavy crop, and not more than average for the Poona District, and we may take it that the Bellary mill as worked at Hirekerur left, unexpressed juice equivalent to 800 lbs. *gul* per acre of good crop, whilst the wooden mill probably left 2,000 lbs. *gul* per acre of good crop. The cost of the Poona mill could thus easily be recovered in a single season, owing to its more effective work. The question may be raised whether the respective mills were properly adjusted for effective work. The Poona mill certainly was, because the percentage of juice expressed is the percentage ordinarily obtained from good cane. We may assume that the cultivators had the other mills adjusted for work to the best of their knowledge. The manufacturer of the Bellary mill possibly, if he had been present, could have adjusted it better. The officer in charge was fully instructed regarding the manner in which the trials should be conducted, and had express orders to prevent any attempts to work the cattle in any of the mills beyond their ordinary pace, whilst the trials were in progress, and generally to see that the trials were complete in every respect.

Comparative statement showing the work of the three sugarcane mills tried at Hirekerur, Dhárwár.

Name of the Mill.	Weight of Cane.	Weight of Juice.	Weight of *Gul*.	Percentage of Juice to Cane.	Percentage of *Gul* to Cane.	Value of *Gul* produced in a Day.	Loss of Juice in a Day, taking Poona Mill as the Standard.	Value of *Gul* or Juice thus lost per Day.
	Lbs.	Lbs.	Lbs. oz.	Lbs.	Lbs.	Rs. a. p.	Lbs.	Rs. a. p.
Dhárwár wooden mill with three rollers.	2,343	1,335	299 0	56·97	*12·76	18 0 2	258 (57·7 *Gul*).	3 7 7
Bellary iron mill with three rollers.	2,197	1,395	313 8	63·79	*14·33	18 14 2	92 (20·6 *Gul*).	1 3 10
Poona iron mill with three rollers.	3,832	2,640	528 0	68·00	†13·60	37 2 11	..	..

* Scum not removed during boiling process. † Scum removed during boiling process.

The cost of labour for each mill per day for cutting, carrying and crushing cane and sugar boiling is shown below, also other details (labour being charged at ordinary hiring rates).

Name of the Mill.	Weight of Cane crushed.	Time occupied in crushing.	Weight of Juice obtained.	Weight of *Gul* obtained.	Number of Boilings per Day.	Labour for cutting, carrying, crushing, and boiling, &c.			Remarks.
						Work people.	Bullocks.	Amount.	
	Lbs.	H. M.	Lbs.	Lbs. oz.				Rs. a. p.	
Dhárwár wooden mill with three rollers.	2,343	9 50	1,335	299 0	3	5 men 2 boys	4	2 8 0	Man 4 annas per day. Boy 2 annas per day. Bullock 4 annas per day.
Bellary iron mill with three rollers.	2,187	9 21	1,395	313 8	3	5 men 1 boy	4	2 6 0	
Poona iron mill with three rollers.	3,882	8 33	2,640	528 0	3	9 men 2 boys	8	*4 8 0	

The first mill is a wooden mill with three vertical rollers fixed side by side in a wooden frame, similar in construction to the mill described on page 126. To work this mill, one man, one lad, one boy, and four bullocks, in relays two at a time, are required ; the man to feed the mill, the lad to pass the cane a second time through the mill, and the boy to drive the bullocks.

The following are the measurements of the different parts of the mill :—

Diameter of the middle roller	1'-6"
Do. of one side roller	1'-3"
Do. of the other side roller	1'-1"
Length of each roller	3'-6"
Length of the beam (draft pole)	8'-4"

This mill at ordinary speed makes 162 revolutions per hour.

The second mill is a three-roller iron mill. Two of the rollers are of the same size, and the third is smaller in diameter. They are set vertically in a triangle. This mill is very useful for small sugarcane areas. The cane, as it passes through, is double squeezed. One man only, therefore, is required to feed the mill. A boy or lad can drive the two bullocks. Four bullocks are required for a full day's work, in relays, two at a time.

The measurements of the different parts of the mill are as under :—

Diameter of the larger roller ...	0'-8"
Do. smaller roller ...	0'-4½"
Length of the roller	0'-10"
Do. beam (draft pole) ...	8'-0"

This mill at ordinary speed made 166 revolutions per hour.

* The work people had not got experts at the work like Poona cultivators, and the work done in a day with the Poona mill at Hirekerur was about three-fourths of that usually done by contract work near Poona. Four boilings per working day are always done at Poona with manual and bullock labour, equal to that used at Hirekerur, contract wages being, for bullocks and men, Rs. 5 per day.

The Poona mill described on page 124 costs Rs. 120, the Bellary mill Rs. 125, and the wooden mill any price between Rs. 35 and Rs. 50, depending upon size, &c.

The pan commonly used in the district has a diameter of 5′-2″ at the top, and is 11″ deep at the centre, and is saucer-shaped.

It is a common practice in the Dhárwár District to mix about 4 ozs. of slaked lime to a pan of 465 lbs. of juice immediately after it is poured in for boiling. People believe that the jagri thus made is harder. The scum, although it rises during boiling, is not skimmed off, and so dark coloured jagri is produced. When the comparative trials were commenced, people visited every day in numbers, and always asked why no lime was used. They noticed the bright colour of the jagri made by the Poona method, and thought it was due to the non-admixture of lime with the juice, whereas it was really due to the removal of the scum by skimming. To prove that the reason assigned by the people was wrong, about 2 ozs. of lime was mixed to a pan, and the jagri was in no way discoloured.* Then the people began to say, "There is much loss in throwing away the scum." An experiment was, therefore, made at a cultivator's *gurhál* with the following results :— *Gul* making.

Boiling.	Cane crushed.	Juice obtained.	Jagri obtained.	Percentage of Jagri to Cane.	Value of Jagri per Rupee.	Value of Jagri.
	Lbs.	Lbs.	Lbs. oz.		Lbs.	Rs. a. p.
Scum not removed ...	729	465	104 8	14·4	16·6	6 4 3
Scum removed	729	465	97 8	13·3	14·2	6 13 2

The above statement shows a loss of 7 lbs. of jagri when scum was removed. But this was made good by the higher rate obtained when sold. The people were satisfied, but I am not at all sure that quality is always appreciated. In some parts of the Presidency neither the wholesale buyer nor the consumer pays much attention to quality. In parts of Gujarát no skimming is done, and there bright, well prepared Poona jagri is objected to, because it lacks flavour.

The only other point on which the people argued was as regards the hardness of the respective blocks of jagri, and which would keep longest during the monsoon. The question was left in abeyance, as it could not be settled off-hand, like other objections.

* If the question of discolour was the one at issue, then for fair comparison 8 ozs. for a full boiling of the Poona pan ought to have been used, and that amount would probably have discoloured the jagri. Lime sufficient to nearly neutralize the acidity of the juice only should be added. If used in excess of this, Dr. Leather has proved that it does discolour the jagri. The actual effect of adding lime in proper quantity is to reduce the percentage of molasses in the *gul*, and thus make it harder, so that it will keep better.

In Dhárwár jagri is not solidified into blocks as in Poona. As soon as the pan is ready, it is removed from the fire, and stirred for a minute or so, and emptied directly into a *pack* (pit) which is made in the ground, 3 feet long, 2 feet 3 inches wide, and 4 inches deep. The *pack* or pit is sided with planks. The next day the jagri in the *pack* has set hard, and is cut into twelve pieces, each 9″ square and weighing from 5 to 7 lbs. While cutting the *pack*, there is generally about 4 or 5 lbs. of broken jagri which the owner keeps for home use. The Dhárwár cultivator shows poor ingenuity in solidifying his *gul*. The Poona method described on page 128 is much better, so also is the Madras plan of using a wooden mould divisioned into cells; but the Gujarát plan of storing in earthenware pots is best of all.

The dry leaves of sugarcane are not used for boiling jagri. They are sold for thatching. Firewood and sugarcane refuse are used for boiling.

In Dhárwár there is not a special man to attend to the boiling as at Poona. The man that feeds the fire also looks after the boiling. The juice for one boiling weighs about 465 lbs., just about half the quantity usually boiled in the Poona boiling pan.

Marketing *gul*.

In the Poona District the *dheps* are sold by the *palla* of 120 *seers* or 240 lbs. By custom 246 lbs. go to the *palla*. Generally throughout Gujarát it is customary to put *gul* into earthenware pots. When sold, a deduction of 5 *seers* per maund or 12½ per cent. is allowed on account of the pots; but usually the actual weight of pots exceeds this allowance. There is a decided advantage in storing *gul* in this manner, because, if soft, there will be no loss of treacle by drainage. Moreover, the *gul* can easily be protected from flies and other insects. When sold by retail, one side of the pot is broken off, and the *gul* is easily removed in small quantities. In Khándesh the potters who provide the earthen pots claim the crushed cane (*megass*) as their perquisite. They extract by lixiviation a small amount of inferior *gul*, and use the residue for burning pots and bricks.

Comparative manuring Experiments at the Mánjri Experimental Station near Poona.

Results of two years' experiments recorded.

These experiments were begun in 1894-95, but the plots were not manured in that year in accordance with any definite standard, and were, therefore, unequally manured. Moreover, after a year's experience, it was found expedient to modify the original scheme considerably. The results which I shall record are those of 1895-96 and of 1896-97. The former crop was newly planted cane, the latter was a ratoon crop grown from the root stocks of the previous crop.

Objects of the experiments.—To test the comparative values of such manures as are within the reach and means of ordinary cultivators, and

when the effects of the various manures have been clearly demonstrated, then to determine whether two or more of the manures used cannot be judiciously combined so as to secure economy.

In both years the various manures each contained 500 lbs. per acre of nitrogen. The percentages of other elements of value are known, and in years to come it may be found that marked differences between the crops of the various plots may be traced to the value of elements other than nitrogen. If this can be done, the value of the experiments will be enhanced, and information be gained which will indicate how two or more manures should be mixed to give the most paying results.

Several edible oil cakes tested as manures in comparison with those ordinarily used.

The manures which the cultivators of the Poona District ordinarily use are poudrette, cattle dung, fish manure from the Thana coast, castor cake and *karanj* (*Pongamia glabra*) cake. In both years we have tested, and will continue to test in comparison with the foregoing, several edible cakes which are now used for feeding cattle in India or are largely exported. These cakes can be bought in Poona at a considerably cheaper rate per ton than the castor and *karanj* cake now so extensively employed as manure. Dr. Leather's analysis shows that the edible cakes contain much higher percentages of nitrogen (the most valuable constituent of manures) than the manure cakes, and our tests indicate that these edible cakes can be employed with economy and success as manure. It has been suggested that the use of edible cake as manure is surely a wasteful practice. My answer to that is that it is surely a much more wasteful practice to feed milch and work cattle with cake and other concentrated food and permit the solid excrement to be burnt as fuel and the urine to be lost. If edible cake is used directly as manure, something is returned to the land which will help to maintain fertility. It might be urged that work and other cattle can only be kept in efficient condition if partially fed on cake or other concentrated food, and, therefore, it becomes necessary to show that the increased production of cane through the use of edible cakes as manure more than compensates for the cost of stimulating food given to cattle. This is difficult to show in black and white. At the same time, the fact that an application of 3 tons per acre of edible cake is capable of producing as much as 12,000 lbs. of crude sugar per acre as food for men and 12,000 to 15,000 lbs. of green tops as fodder for cattle proves that edible cake is put to a good use when used as manure. I admit it would be put to a better use if fed to cattle, provided the solid and liquid excrements are properly conserved and used as manure.

There is no definite relationship between the values of the manures as determined by chemical analyses and their commercial value. It is

No definite relationship between the commercial value of manures and their value according to chemical analysis.

certain that the cane growers of the Poona District, though much above the average in intelligence, fail to recognise the difference in manurial value of the manures they use.

The results of our comparative manure experiments are not only intended to prove which manures in given quantity are most effective for sugarcane, but also which manures are cheapest. It may be that when a particular manure is shown to be cheap its extended use will soon make it dear, but there will be an advantage to somebody.

Farm yard manure probably the cheapest manure a cultivator can use.

Farm yard manure and cattle dung are charged at full local rates, but it is right to notice that these rates are four times as high as cattle dung sells for in out-districts where irrigated crops are not grown. It will probably be found eventually that, at out-district rates, cattle dung will be proved much the most economical manure that a cultivator can use; because considering its chemical composition, it is much the cheapest. The value for manure will vary with the food given to the cattle and the care with which it is preserved with litter and urine. Properly saved farm yard manure will not, as our experiments indicate, be weight for weight as valuable as pure dung, but then the manure pit will be filled much more quickly with the former than the latter. The dung from poorly nourished animals is considered by ordinary cultivators just as good as that from those highly fed. Both descriptions are with equal readiness used as fuel. In almost all districts the value of cow dung as fuel is as great or greater than its value as manure, because wood is scant and dear. In the Poona District this is notoriously the case. Therefore, it is not surprising that a cultivator of cane sells the dung of his cattle as fuel, and buys poudrette, oil cake, &c., for his crop.

Quick acting manures give the best results, especially in the case of new cane.

Although the quantity of each manure applied in the "Comparative Manure Series" contained 500 lbs. of nitrogen, there were very great differences in outturn between the various plots. This was particularly noticeable on the new cane, not to such an extent with ratoon. Ratoon cane owing to its greater root development is able to get nutriment from a slow acting manure much more effectively than new cane does in the early stages of growth. At any rate the differences between the plots of new cane were, in a great measure, due to variation in the activity and effectiveness of the various manures. Ratoon cane springs into active and vigorous growth at once, and at the early stage there was no appreciable difference between its various plots; but in the case of new cane it was clear that some of the manures acted far more actively than others. How far the action was due to the presence in the manures of elements other than nitrogen can only be conjectured at this stage of the experiments. The practical fact remains that cer-

tain manures, *i.e.*, fish manure, poudrette and some oil cakes, had quicker action than other oil cakes and much quicker action than cow dung or farm yard manure.

Slow acting manures caused uneven germination.

On plots with slow acting manures, germination was irregular, and the young shoots which did grow were obviously starved and checked in growth. This check was never afterwards recovered.

Oil cake made in country *ghâni* extremely quick-acting.

Oil cakes as made in Europe are generally considered to be slow in their action as manure. Oil cakes as made in the ordinary country *ghâni* are extremely quick in their action. In India oilseed as ordinarily pressed is ground up into an impalpable powder as the oil is expressed. The oil cake is consolidated during the process, but before it is applied as manure it is again powdered, and I have no doubt the minute particles of cake again disintegrate into impalpable powder when brought into contact with the moisture of the soil. It is easy to understand that manure in such a fine state of division will very soon show its effects upon a crop. The method of preparing cake in Europe and in the hydraulic press mills in Bombay is quite different. The seed is crushed, but not into fine particles. The crushed seed is cooked or steamed. Thus the oil freely escapes from the oil cells. The cooking of the crushed seed would of necessity convert the albuminoids into a much more insoluble condition than that in which they exist naturally. The albuminoids contain nearly all the nitrogen of the seed, and it is reasonable to suppose that the nitrogen as it exists in hydraulic pressed oil cake does not become available as plant food nearly so soon as that in oil cake made in the ordinary country *ghâni*.

Hydraulic pressed cake slow in action for reasons given.

The results of the comparative manure experiments which I tabulate below under Series A and Series B will be better understood from the above explanations.

Period of growth.

The new cane was cut in 11½ to 12 months after plantation. Those plots which germinated well and were dressed with quick acting manures ripened soonest. The ratoon cane was cut 10 to 10½ months after the previous crop was reaped.

Manures applied partly before plantation, partly as a top-dressing.

In 1895-96, the manure was applied three-fifths before plantation in March and two-fifths in July. In 1896-97, the ratoon plots were manured with three-fifths of the application in May and two-fifths in July. It is not customary to give manure to a ratoon crop until it has made considerable growth.

Experiments conducted since 1897 have proved that safflower and niger seed oil cakes are cheap and extremely effective manures for sugarcane, and that applications containing 350 or 400 lbs. of nitrogen are necessary to give the best results in new cane. A dressing of about 250 lbs. nitrogen per acre is sufficient for ratoon cane.

Comparative Manures, Series A, 1895-96 and 1896-97.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of *Gul* per Acre.	Percentage of *Gul* to Cane.	REMARKS.
			Tons.	Lbs.	Rs. a.	Lbs.	Lbs.	Lbs.		
2	Safflower cake.	1895-96. New cane.	3·3	500	169 6	95,655	12,520	12,320	12·8	Planted 1st April 1895, harvested 23rd to 27t March 1896. Germination very regular. Crop had throughout an extremely healthy appearance, the leaves until the crop ripened being of a rich dark-green colour. Irrigated 27 times.
		1896-97. Ratoon cane.	3·9	500	185 13	71,760	..	8,430	11·7	Harvested 15th-16th January 1897. Crop looked vigourous and healthy throughout. Irrigated 16 times.
3	Bassia cake (*mhowra*). *Bassia latifolia.*	1895-96. New cane.	5·6	500	323 9	72,410	12,980	7,725	10·6	The first application of Bassia cake had apparently a poisonous effect. Only a set here and there germinated, re-planted and then germination was quite satisfactory. The top-dressing of manure given in July showed no harmful results. The crop from the second planting made steady, vigourous progress. It was not fully ripe when harvested. If left longer, the results of the next crop would be interfered with. Planted on 1st April 1895, replanted on 8th May 1895, harvested 23rd, 28th March 1896. Irrigated 27 times. The low percentage of *gul* to cane indicates that the crop was not fully ripe.
		1896-97. Ratoon cane.	5·3	500	299 7	68,820	..	7,895	11·5	Harvested 15th January 1897. Regular germination. Healthy growth throughout. Irrigated 16 times.
6	Cotton-seed cake.	1895-96. New cane.	7·1	500	316 0	83,300	14,925	10,280	12·3	The cake was got from a Bombay mill which, however, has stopped the manufacture, because the percentage of oil got from Indian seed is small and does not pay. The crop had a very thriving appearance throughout. Planted 31st March 1895, harvested 28th to 31st March 1896. Irrigated 27 times.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of *Gul* per Acre.	Percentage of *Gul* to Cane.	REMARKS.
			Tons.	Lbs.	Rs. a.	Lbs.	Lbs.	Lbs.		
6	Crushed cotton seed.	1896-97. Ratoon cane.	6·5	500	362 1	73,645	..	9,050	12·3	Crushed cotton seed was substituted for cotton seed cake, the latter not being obtainable. It is believed that in districts where cotton is grown, and where the seed is very cheap, it will probably be found an economical manure for sugarcane grown in the same districts. The dark green colour of the leaves of the cane was conspicuous in comparison with some of the other plots of the series. Reaped 12th-13th January 1897. Irrigated 16 times. The price paid for the cotton seed is much dearer in Poona than in cotton growing districts.
7	Fish manure.	1895-96. New cane.	2·9	500	188 12	90,485	11,415	11,990	13·2	The evenness of germination and vigour of growth were nearly as conspicuous as in Plot 2. The manure must be ploughed in or dug in deeply; otherwise crows, jackals, dogs and pigs are attracted. Crop planted 31st March 1895, reaped 10th to 17th March 1896. Irrigated 26 times. The high percentage of *gul* to cane is noticeable.
		1896-97. Ratoon cane.	2·7	500	164 7	76,845	..	9,050	11·7	Reaped 12th and 13th January 1897. Irrigated 17 times.
8	Castor-cake.	1895-96. New cane.	5·9	500	303 10	80,770	13,010	9,820	12·1	Germination and tillering quite satisfactory, but the crop had not the thriving, vigourous appearance and healthy colour of the best plots in the series. Planted 31st March 1895, harvested 11th to 17th March 1896. Irrigated 26 times.
		1896-97. Ratoon cane.	6·2	500	292 11	79,400	..	9,780	12·3	This plot gave the best crop of the whole series. Harvested 11th and 12th January 1897. Irrigated 17 times.

Manuring experiments.

	Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	REMARKS.
				Tons.	Lbs.	Rs. a.	Lbs.	Lbs.	Lbs.		
Manuring experiments.	9	Karanj cake. (*Pongamia glabra.*)	1895-96. New cane.	6·6	500	280 0	83,270	10,915	9,770	11·7	Very little difference in the appearance of this and the adjoining castor cake plot. Planted 31st March 1895, harvested 12th and 17th March 1896. Irrigated 26 times.
			1896-97. Ratoon cane.	5·3	500	203 7	70,600	..	8,445	12·0	Reaped 10th and 11th January 1897. Irrigated 16 times.
	12	Poudrette.	1895-96. New cane.	22·3	500	150 8	80,720	11,455	10,455	12·9	Results conspicuously good as compared with some other manures. Our results and chemical analysis indicate that the manure is a cheap, if not the cheapest, source of nitrogen in India even at the Poona price which is very high. This manure is only obtainable at populous centres; costly to transport. Crop planted 30th March 1895, harvested 13th to 19th March 1896. Irrigated 26 times.
			1896-97. Ratoon cane.	20·1	500	179 13	55,405	..	7,410	13·4	The crop was somewhat disappointing. Germination was satisfactory, but the crop at no stage of growth had the thriving appearance of the previous year's crop. Harvested 8th and 9th January 1897. Irrigated 16 times.
	13	Cattle dung from ordinary fed cattle.	1895-96. New cane.	25·1	500	160 0	60,490	12,220	7,510	12·4	The results compared with some other plots are poor. Heavy dressing of the same manure was given in the previous year to the plot also with poor results. The inference is that cattle dung is slow in its action. The germination was quite regular, but the crop had throughout a yellow, unhealthy appearance. Planted 30th March 1895, harvested 20th and 21st March 1896. Irrigated 27 times.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of *Gul* per Acre.	Percentage of *Gul* to Cane.	REMARKS.
			Tons.	Lbs.	Rs. a.	Lbs.	Lbs.	Lbs.		
13	Cattle dung from ordinary fed cattle.	1896-97. Ratoon cane.	18·9	500	127 12	70,445	..	8,150	11·6	This plot gave much more satisfactory results under ratoon cane than in the previous year. Owing to the well-known lasting effect of cattle dung, the crop probably benefited by the unexhausted residues of the same manure applied during the two previous years. Harvested 7th and 8th January 1897. Irrigated 15 times.
		1895-96. New cane.	29·0	500	194 14	53,790	11,175	6,950	12·9	The remarks made against Plot 13 apply equally to this plot. Crop planted 30th March 1895; harvested 20th to 24th March 1896. Irrigated 27 times.
11	Cake-fed cattle manure mixed with urine and litter.	1896-97. Ratoon cane.	25·09	500	142 12	62,205	..	7,870	12·6	Ratoon crop more satisfactory than the previous year's crop of new cane. It is, however, clear that there are more satisfactory manures for sugarcane than either farm yard manure or cattle dung. Crop harvested 7th January 1897. Irrigated 16 times.
		1895-96. New cane.	3·4	500	162 0	63,600	10,960	7,900	12·4	The cake used is a hydraulic pressed cake made in Bombay from coarsely ground steamed seed. For this reason the cake possibly acts slowly. The results are poor for a cake so rich in nitrogen and compare unfavourably with the other oil cakes, which, however, were all made in the country *ghâni*, and, therefore, probably acted more quickly. Planted 30th March 1895; harvested 1st to 23rd March 1896. Irrigated 27 times.
15	Safflower and groundnut cake.	1896-97. Ratoon cane.	3·6	500	158 15	68,030	..	7,680	11·3	The crop looked fairly promising during the whole period of growth, but the outturn of *gul* is rather disappointing. It may clearly be inferred that hydraulic-pressed cake made from coarsely ground steamed seed is slow in action, even though rich in nitrogen. Harvested 18th and 19th January 1897. Irrigated 16 times.

Comparative Manures, Series B, 1895-96 and 1896-97.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of *Gul* per Acre.	Percentage of *Gul* to Cane.	REMARKS.
			Lbs.	Lbs.	Rs. a.	Lbs.	Lbs.	Lbs.	"	
Manuring Experiments.		1895-96. New cane.	3,520	130	116 0	32,145	8,875	3,905	12·1	A heavy application of bones (5 tons per acre) was given to this plot in the previous year with poor results. It might reasonably have been expected that the residue left would have benefited the crop of this year. There is nothing to indicate that such is the case. The action of bones is so slow that they cannot be economically used as manure for sugarcane. The crop had the appearance of being starved throughout its growth. Planted 1st April 1895; reaped 25th to 27th March 1896. Irrigated 27 times.
4	Bone meal.									
		1896-97. Ratoon cane.	3,343	130	122 14	30,900	..	3,705	11·9	The results this year with ratoon confirm the above remarks. Reaped 14th January 1897. Irrigated 16 times.
		1895-96. New cane.	3,520 Bones dissolved in acid.	130	196 0	36,275	8,535	4,950	13·6	Manured with 6 tons per acre dissolved bones in previous year. Crop fair, but cost of such a heavy dressing of manure entirely prohibitive. This year manure made on farm Acid of ordinary commercial strength used; 640 lbs. acid to 3,520 lbs. bone meal The price of the manure is entirely prohibitive for ordinary cultivation in the Poona District. Planted 1st April 1895, harvested 27th and 28th March 1896. Irrigated 27 times.
5	Dissolved bones.									
		1896-97. Ratoon cane.	4,404 dissolved bones or 3,343 crushed bones dissolved in acid.	130	207 5	54,845	..	6,365	11·6	Better results, but not good enough to pay, considering the expensive dressing of manure. Reaped 13th and 14th January 1897. Irrigated 16 times.

Plot Number.	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre.	Cost of Manure per Acre.	Weight of Cane stripped topped per Acre.	Weight of Tops per Acre.	Weight of *Gul* per Acre.	Percentage of *Gul* to Cane.	REMARKS.
			Lbs.	Lbs.	Rs. a.	Lbs.	Lbs.	Lbs.		
10	Bone meal and crude nitre.	1895-96. New cane.	3,520 bone meal, 1,290 nitre.	250	264 0	41,000	10,075	5,015	12·2	One-fifth of the nitre was applied before plantation; the rest in four equal top dressings given in June, August, October and December. It was believed to be economical to apply the nitre in top dressings, because, being very soluble, it is easily washed away in drainage if not taken up by the crop almost at once. The crop did not benefit to the extent that was expected, and the cost of the manure exceeded the value of the crop. Planted 30th March 1895; harvested 30th and 31st March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	3,343 bone meal, 1,230 nitre.	250	255 0	50,385	..	4,900	9·7	Nitre applied in 5 top dressings at intervals as above. The cane only yielded 53·7 per cent. juice, whereas the average of all other manure plots was approximately 68 per cent. The percentage of *gul* to cane is very low. I can offer no satisfactory explanation. Again, the cost of the manure about equals the value of the crop. Reaped 9th and 10th January 1897. Irrigated 15 times.
11	Dissolved bones and crude nitre.	1895-96. New cane.	3,520 bone meal dissolved, and 1,290 nitre.	250	344 0	65,715	11,695	8,135	12·8	Nitre applied as in Plot 10 for similar reasons. It is clear that dissolving the bones makes the manure more effective, but the cost is entirely prohibitive. Crop planted 31st March 1895; reaped 29th to 31st March 1896. Irrigated 27 times.
		1896-97. Ratoon cane.	3,343 bone meal dissolved, or 4,400 dissolved bones and 1,230 nitre.	250	344 6	62,905	..	7,845	12·5	Nitre applied as above. Crop reaped 8th and 9th January 1897. Irrigated 15 times.

Manuring experiments.

Cost of cultivation.

The estimated cost per acre of cultivating sugarcane by hired labour in the Poona District is as follows :—

	Rs.	a.
First ploughing in November : 4 team plough does an acre in 4 days ; 1 ploughman and 2 boys or lads driving	10	0
Second and third ploughing in December	12	0
Levelling with log harrow twice and breaking clods by hand implement	3	0
Manure ; cartage and spreading 25 tons poudrette per acre	180	0
Ridging ; ridges 24" apart ; 3 team plough, 1 ploughman, 1 driver ; 1 acre per day	2	8
Making water compartments ; contract rate	2	4
Value of sets, 18,000 per acre	50	0
Carrying sets to field ; first watering and planting	5	0
Watering 32 times in a year ; 1 man for 5 acres at Rs. 7½ per month	18	0
Hand weeding ; first weeding a month after planting and other three at intervals as required until June	12	0
Digging and making new beds in July	10	0
Water rate (canal water)	40	0
Cost of constructing *gurhâl* ; Rs. 10 or Rs. 3 per acre...	2	0
Hire of sugarcane mill and other apparatus ; Re. 1 per day or Rs. 16 per acre	16	0
Harvesting and *gul* making at contract rate of Rs. 5 per 600 lbs., say	85	0
Marketing *gul* and commission to *Dalâl* as at Poona. Crop, 40 *pallas* of 246 lbs. per acre	39	0
	486	12
Value of crop ; 40 *pallas* at Rs. 14 per *palla* (price varies in any season from Rs. 12 to 18)	560	0

In growing a ratoon crop the cost of preparatory tillage is trifling. No sets are required ; less manure is required than for new cane. The crop requires less irrigation than new cane, and altogether the saving in the cost of cultivation as compared with new cane is Rs. 120 to Rs. 150 per acre. A ratoon crop which has thriven well yields as much *gul* per acre as a fairly good crop of new cane. On page 114 I have shown the actual cost of cultivation in an experimental plot at Mánjri at Rs. 325 per acre and value of produce at Rs. 447.

Conf. Agricultural Ledgers, Nos. 18 of 1895, 19 of 1896, and 3 of 1897.

Dr. Leather's investigations into the chemistry of the sugarcane crop have been published in full detail in the *Agricultural Ledger* (*Medical and Chemical Series Nos. 1, 4, and 9*). The following is a succinct resumé of the work as published in paragraphs 114 to 128 of Dr. Leather's Final Report :—

"114. The investigations may now be conveniently referred to under the following heads :—

(1) The composition of the juice—(*a*) in cane which had been transferred to long distances ; (*b*) in cane which had been grown with varying amounts of manure ; (*c*) in cane which had become *lodged* ; (*d*) in the top ends of the cane ; (*e*) in different varieties of cane.

(2) The relation between the amount of sugar in juice and its specific gravity.

(3) The determination of the amount of inversion which takes place during the concentration of the juice.

(4) The amount of sugar which becomes lost in the scum.
(5) The composition of the raw sugar, *gur*, *gul*, and *rás*.
(6) The refining of sugar by means of the hand centrifugal separator.
(7) The total amount of sugar in cane and the amount remaining in the crushed cane.
(8) The amount of phosphoric acid and nitrogen in the sugarcane crop.

Chemistry of sugarcane.

"115. (1—*a*)—*The composition of the juice of cane which had been transferred to long distances.*—In the course of the experiments under reference, several varieties of cane have been transported to considerable distances. In 1894 two varieties were sent from the Mauritius to Poona—one a white and the other a red variety. They were grown at Poona with very liberal amounts of manure, and, so far as appearances went, both crops were splendid. They were reputed to give a juice containing some 18 per cent. of sugar. But at Poona the juice of both has contained much less than this amount. In 1895 the juice of the white variety contained about 12 per cent. of cane sugar and 1·4 of glucose; that of the red variety about 10 per cent. cane sugar and 2 of glucose. In 1897 (the third crop) the corresponding figures were 14·71 per cent. cane sugar and 0·99 of glucose in the juice of the white, and 12·7 of cane sugar and 1·5 of glucose in that of the red variety. Thus, although the juice is still poorer than it ought to be, a material improvement has manifested itself during the three years.

"A second example of this nature occurred in the case of the Poona *pundia*, the variety commonly grown around Poona. This cane at Poona has been found to contain from 16 to 18 per cent. of total sugar. It was sent to Cawnpore and Dumraon in 1895, but the crops at both farms produced a juice containing only 14 per cent. of total sugar in the 1895-96 crop, and there was just about the same amount in the crop of 1896-97.

"Some further evidence was gained during the past season. A number of varieties, commonly grown in the Bombay Presidency, were collected in 1895 and grown at Poona in 1896. These crops were then analysed in the succeeding cold weather. Immediately afterwards I visited villages in the neighbourhood of Belgaum and Dhárwár, and analysed some of these same varieties in their native place, and it was then found that in three cases the quantity of the juice was much lower, in two instances it was higher, and in one it was the same at Poona as in the crops at Belgaum and Dhárwár. Thus the evidence at hand points to the conclusion that transference of cane from one country to another may cause a material alteration in the development of the plant generally resulting in depreciation of the juice. The evidence given by the Mauritius varieties, however, indicates that the cane will gradually assume a normal composition in the course of a few years.*

"116. (1-*b*).—*The composition of the juice of cane which has been grown with varying amounts of manure.*—One of the questions which naturally presented itself at the commencement of the experiments was, 'What effect has manuring on the quality of the juice of sugarcane?' The plots at Poona and at Cawnpore received in each case very varying amounts of manure, and the question appeared to be one which would be readily solved. Accordingly, one or more samples of the juice of the cane from each of the plots in question at these two farms were analysed during the harvest. The results at first obtained are quite uniform.

"The cane at Poona (*pundia*) was grown with a series of different manures, varying very much in amount, the nitrogen from 130 to 1,000 lbs. per acre, and the phosphoric acid from 140 to 2,700 lbs. per acre; in all cases the amount of manure was large. The percentage of both cane sugar and glucose was found to be very constant in each year, namely, from 15 to 17 per cent. of cane sugar and 1·0 to 1·8 per cent. of glucose.

* This is confirmed by the remarkable manner in which the Southern Maratha varieties recovered to their normal standard in the second year of cultivation at the Poona Farm, although they had deteriorated considerably in the first year's cultivation. (*See* description of Bombay varieties, pages 159 to 170.)—J. M.

"At Cawnpore a small cane, the *matna*, was grown in 1894-95 and 1895-96, with different descriptions of manure, in varying amount (the nitrogen varied from *nothing* on the unmanured plot to nearly 200 lbs. on the most heavily manured plot), the weight of manure being in all cases very much smaller than was the case at Poona. Again, the analyses of the juice of this cane showed no relation between the amount of manure applied and the quality of the juice: the cane-sugar varied from 14 to 17 per cent. the first year and from 15 to 17 per cent. the second year, and the glucose from ·3 to ·5 per cent. Thirdly, at Cawnpore in 1896-97 another variety was grown, a thick *pundia* called *madrási*, and this was manured with different materials containing from 200 to 500 lbs. nitrogen per acre, the amounts being in every case *large*. The percentage of cane sugar varied from 14 to 15·5 per cent. and the glucose from 0·5 to 0·9 per cent.

"Thus the evidence adduced from three somewhat extensive series of tests pointed uniformly to the conclusion that neither the kind of manure, nor its amount, exercised any influence on the quality of the juice of sugarcane.

"It so happened, however, that conflicting evidence was met with during the cold weather of 1896-97 at Cawnpore. Six varieties—three thin ones and three thick ones—have been grown at this farm for three years. One of these was the *matna* variety already alluded to. In 1896, it was decided to grow this variety (along with the others) with large amounts of manure. It now grew much taller than usual, and the weight of crop was much increased. When, however, the juice came to be analysed, it was found that, instead of containing the 15 to 17 per cent. of cane sugar which had been maintained for two years, the proportion had fallen to 11 per cent.; on the other hand, the proportion of juice expressible by the mill, which had previously been 45 to 50 per cent., was now found to be 60 per cent.

"Another piece of similar evidence was obtained in connection with the Dumraon experiments, where it is probable that high manuring had, in the case of certain canes, reduced the proportion of sugar. But a consideration of the evidence on this subject clearly offers an explanation of the effects noticed.

"It is certain that under the conditions of growth of the Poona *pundia*, the *matna*, in 1894-95 and 1895-96, and the *madrási* in 1896-97, manuring had *no* material effect; and those conditions are readily set out. The Poona cane is commonly grown with large amounts of manure, and it was similarly supplied in the experiments. The *matna* is commonly grown with only small amounts of manure, and only small amounts were supplied to it at Cawnpore in the first two years. Thirdly, the *madrási* variety is commonly heavily manured, and the treatment for it was similar in this respect at Cawnpore in 1896-97. Thus, *while the conditions of manuring assimilated to those to which the several varieties are accustomed*, the proportion of sugar remained normal, whereas, if the one or two cases of sudden change in the composition of the juice due to heavy manuring are to be relied on, it would appear that a variety *may* produce a poor juice, if it be suddenly grown with much larger amounts of manure than those to which it has been accustomed for long periods.

"It must not be supposed, however, that a less outturn of sugar was realised in the case of *matna*. Although the percentage of sugar in the juice was less, much more juice was obtained, and the crop was about twice as heavy. So that, from the economic point of view, there was a considerable gain. Moreover, the evidence, such as it is, of the varieties at Dumraon, point to the fact that under the new conditions the varieties will regain their normal growth in the course of a few years. The case is indeed very similar to that referred to in paragraph 115, where the effect of change of climate is discussed, and it seems likely that a cane may suffer from either cause; the effects are, however, probably only temporary.

"117. (1-*c*).—*The composition of the juice of cane which had become lodged.*—The crop of cane at Cawnpore was much lodged in 1894 by rain, and it was decided to crush the fallen cane separately from that which remained erect. It was then found

that the juice of the lodged cane contained *much* less sugar than that in the standing cane, and the *gur* prepared from it was so full of molasses that it would not solidify. In the other two years the weather was not abnormally wet, and no further evidence of the effects of heavy rain has been obtained; but the crops at Cawnpore and Dumraon were so heavy in 1896 that some parts fell down. The juice of the fallen cane was again separately examined, with the result that it was found to contain generally a less proportion of cane sugar, and a larger one of glucose, than was found in the standing cane. The differences were on the whole not great, and nothing like so serious as was the case with the crop which had been *lodged by rain* in 1894.

"118. (1-*d*).—*The composition of the juice of the top ends of the cane.*—My attention was directed to the quality of the juice in the top ends of the cane, because in the Burdwan District of Bengal it is customary to propagate the crop from the top ends only, whilst in most parts of India the usual practice consists in cutting up whole cane into pieces and propagating from them.

"Moreover, it so happens that in no part of India is the cultivation of cane, in most respects, more perfectly carried out than at Burdwan, and one at least of the varieties there grown is an exceptionally good one, containing from 16 to 18 per cent. of sugar. In no respect, therefore, could it be said that the quality of the cane or the cultivation was inferior. Now the weight of cane which is used for sowing is very considerable, amounting to several thousand pounds per acre, and the question naturally presented itself, what sort of juice is contained in the top end of the cane, and is it an economy in the matter of sugar to propagate from the top ends only? Accordingly, several sample bundles of cane were taken at Burdwan this year, the top ends cut off, and the juice expressed and analysed from the top ends and the remaining cane, respectively. The experiment showed quite conclusively that there was much less juice in the top ends than in the main part of the stem, and much less sugar in that juice. Consequently, it is apparent that, if an acre be sown with the top ends of the cane, and the main part of the cane be reserved for sugar-making, an economy in sugar will result. Taking the figures which were obtained in the experiment as a basis of calculation, this economy amounted to about 320 lbs. of raw sugar in the case of one variety, and to about half that amount in the case of another; or we may say that by propagating from the tops only, a saving of several hundred pounds of raw sugar per acre will be realised.

"It appeared desirable that other varieties should be propagated from the top ends only, in order to determine whether any deterioration of quality resulted, and this is being done at Cawnpore with cane which has always been grown from the cut-up whole cane; but unless such deterioration should manifest itself, it must mean a great saving to cultivators to plant from the top ends only.

"119. (1-*e*).—*The composition of the juice of different varieties of cane.*—The amount of juice expressible by the mill, and the proportion of the cane sugar and glucose in the juice, has been determined for a number of varieties, some of which have been grown at the farms, some in villages at a distance from them. The amount and quality of the juice has varied a good deal between the worst and the best.

"The proportion of juice expressible will be dealt with under (7).

"The juice of the better varieties, such as the Poona *pundia*, the *samsára* of Bengal, and the *madrási pounda*, all contain high proportions of sugar varying from 14 to 18 per cent. of total sugar, and I am certain that no better cane can be obtained anywhere than these. Some of the thin varieties, too, such as the *matna* of the North-Western Provinces, *mungo* of Behar and *khári* of Bengal, give a juice containing similarly high proportions of sugar. On the other hand, some such as the *dikchan* and *dhaul* of the North-Western Provinces have much less sugar in their juice. Of the total sugar, the greater part is of course cane sugar.

"The glucose has in most cases been determined in the juice also, and its proportion varies from a half up to two per cent.

"The *acidity* in the juice was determined in a number of samples in 1896, but the results obtained I consider uncertain. The colour of the juice is so dark that a difficulty was experienced in using 'indicators.' The question of the amount and the kind of acidity is nevertheless an important one, for, as will become evident when explaining the experiments which I made to prevent inversion when boiling the juice, this constituent causes a serious loss of crystallizable sugar. What is required is a method, both simple and rapid, for determining the amount of organic acids, other than carbonic acid, which may be used in the field, and I had not time to work one out.

"120. (2).—*The relation between the amount of sugar in sugarcane juice and its specific gravity.*—Owing to the increasingly large number of analyses of juice which it was desirable to make in connection with these sugarcane experiments, and also to the fact that a chemist is only occasionally at the farms at the time of harvest, the need became apparent of some simple method of determining approximately the amount of sugar in juice.

"In the case of sugar being dissolved in pure water, its amount may be determined with very fair accuracy by observing the specific gravity of the solution, there being a very simple relation between the two.

"Sugarcane juice is not, however, a solution of only sugar in water; other substances are present besides, which affect the density. It occurred to me, however, that the amount of these other substances might be fairly constant, and, if so, the insertion of a uniform correction would enable one to calculate the percentage of total sugar from the specific gravity.

"Accordingly, I compared the specific gravity of a large number of samples of juice with the amount of sugar actually found by analyses. The result of this was that the difference between the percentage of sugar as shown by the hydrometer and that actually present proved to be fairly constant as I had expected. This difference amounted to about 2 per cent. in the majority of cases, and I calculated out a set of tables by means of which any one can find out the per cent. of total sugar with the aid of a hydrometer. Of course, such a method is only approximate, but the result will not be more than half a per cent. from the truth. Also it is to be observed, one only learns the amount of *total* sugar by this means, but since the amount of glucose is only small, the method will be found very useful for field work, when the more exact methods of the chemist are not available.

"121. (3)—*The amount of inversion which takes place when boiling down the juice.*—All cane juice contains organic acids, and these at a boiling heat possess the unfortunate property of converting a part of the crystallisable cane sugar into uncrystallisable glucose. So far as the *food value* of the resulting sugar is concerned, the change is probably of no great consequence.

"But in other respects the change is very serious. Not only are molasses useless and inconvenient to the refiner, to the small native refiner, just as much as to the large operator with European appliances, but to the *Bunya* who has to store the *gur* or *gul* through the rains, the matter is of equal importance, because the larger the proportion of molasses, the more liable is the *gur* to liquefy in his *godown*. I found that whereas in *the juice* each 100 parts of total sugar includes usually from 2 to 10 parts of glucose, in the *gur*, as ordinarily made, the proportion of glucose ranged from 10 to 20 parts. In addition, it is to be borne in mind that each part of glucose will prevent an equal weight of cane sugar from crystallizing, so that these figures have to be doubled in order to express the true effect of this glucose formation. In endeavouring to find a means of preventing the change, it was necessary to employ only such a method as the ordinary cultivator could use, and I believe I have more or less succeeded. The addition of a small quantity of quicklime in water will neutralise the acidity of the juice, and thus prevent in a great measure the

process of inversion. Too much lime must not, however, be employed, otherwise the resulting sugar becomes black, and its market value decreased. Litmus paper was at first employed to detect when sufficient lime had been added; later I found that there is a natural colouring matter in the juice which could be equally well employed.

"The result of the careful addition of lime is to prevent very materially the formation of molasses, and the *gur* obtained has a much better crystal. That which has been made at Cawnpore has realised distinctly a higher price in the bazar than that produced by simply boiling down the juice. Likewise in some experiments which I made in villages on Messrs. Thomson and Mylne's estate this year the results were equally satisfactory.

"122. (4)—*The amount of sugar which becomes lost in the scum.*—When boiling down the juice, scum rises to the surface, and is skimmed off more or less perfectly with ladles. The amount of this scum is considerable, and it seemed desirable to make one or two determinations of the amount of sugar which must of course be carried along with it.

"Accordingly, in the cold weather of 1895-96, I estimated very accurately the amount of sugar actually present in the juice, and later, after the *gur* had been made, the amount of sugar in it. The difference between these two amounts is due to the sugar which had been carried away in the scum. Four experiments were made at Cawnpore and four at Poona. The loss of sugar proved to be from 10 to 14 parts per hundred in the juice.

"This sugar which is unavoidably taken in the scum is, however, not wasted. At Poona the people recover part of it by putting the scum into water, boiling the liquid and again skimming off the scum. At Cawnpore the scum is given to cattle as a food.

"123. (5)—*The composition of the raw sugar.*—By far the greater part of the cane juice produced in India is simply evaporated down (after removing the scum) to such an extent that on cooling the mass becomes solid. This description of raw sugar is called *gur* in the North-Western Provinces and Bengal; in the Deccan it is called *gul*. Whilst still hot, the raw sugar is usually run into moulds where it solidifies in blocks weighing from 25 to 100 lbs. Sometimes, as in parts of Oudh, the *gur* is made up whilst warm and soft into rounded pieces about a couple of inches in diameter, and again in other districts, *e.g.*, Dehra Dun, it is run out on bamboo matting whilst hot and allowed to solidify in thin cakes. These are, however, minor practices, and are not deserving of recommendation. Some of the Oudh *gur* proved to be exceedingly dirty.

"The composition and colour of this description of raw sugar will vary very considerably, much depending on both the quality of the juice and the mode of working.

"If the cane becomes *laid* by rain, the juice will contain a high proportion of glucose (*vide* paragraph 117), and the resulting *gur* will be soft. Again, if the juice be poured through a cloth or brass wire strainer, much dirt and bits of cane are separated; it is indeed surprising how much dirt can be removed from the juice by this means. During the boiling process the more perfectly the skimming is effected, the purer will be the product and the better its colour.

"Finally, if the acidity of the juice be neutralised, the *gur* will contain a lower proportion of molasses (*vide* paragraph 121).

"Some samples of cultivators' *gur* from Oudh, which I analysed, contained of cane sugar from 63 to 72 per cent., glucose from 9 to 10 per cent., mineral matter from 3 to 4 per cent., water and other impurities from 15 to 24 per cent.

"The samples of *gur* made from *laid* cane at Cawnpore in 1895 contained from 64 to 68 per cent. cane sugar and 13 to 14 per cent. glucose, whereas the *gur* from the erect cane of the same crop contained from 70 to 75 per cent. cane sugar and 8 to 10 per cent. glucose. But with good cane and careful manufacture, the *gur* will contain from 70 to 78 per cent. cane sugar and from 5 to 15 per cent. of glucose.

"124. In addition to the solid *gur* or *gul*, another description of saw sugar is prepared by removing the mass from the fire at a somewhat earlier stage and before all the water has been boiled out. The resulting sugar never solidifies entirely, but a great deal of the cane sugar crystallises out during the first few days, and the mass becomes semi-solid. It goes by the name of *ráb* in many parts, but in parts of Bengal it is also called *gur*.

"The composition of *ráb* will vary somewhat according to the amount of water which is left in it. That made at Burdwan this year contained from 65 to 73 per cent. cane sugar and 5 to 10 per cent. glucose, but one of the samples was undoubtedly below average for some reason or other. Other samples from Behea, which were prepared in my presence, contained from 69 to 75 per cent. cane sugar and only 3¼ to 5 per cent. glucose, and there is no doubt that, given good cane and careful manufacture, the latter standard can be maintained.

"This description of sugar is prepared specially for the purpose of refining. Frequently it is put into sacks which are then placed one on another in order to increase the pressure on the lower ones, and the molasses gradually run out more or less. Or again the refining process is effected by placing the *ráb* in a vessel having a "false bottom." A wet weed (*sewar*) is then placed on the surface, and the molasses gradually leave the top layer of sugar. This purified layer is then scraped off, and the *sewar* applied to the next layer, and so on until the whole has been refined. In neither of these refining processes are the molasses obtained in a fit state for human consumption, and this means a loss of fully one-third of the sugar operated upon.

"One sample of sugar refined by this process contained 96·6 per cent. of cane sugar and 0·89 per cent. glucose.

"125. (6)—*The hand centrifugal sugar separator.*—Another much better means of separating the molasses from the sugar crystal of *ráb* has been provided by Messrs. Burrows, Thomson and Mylne of Behar, who have introduced a centrifugal machine, worked by one man at a time, by means of which the molasses are separated in a few minutes. About 26 seers of *ráb* are placed in a machine at once, the separation is effected in about 20 to 30 minutes, and the resulting sugar removed and the machine cleaned out ready for the next charge within five minutes. About 50 maunds of *ráb* can be readily worked off in one day by each machine. The molasses are recovered quite clean and sweet, and are boiled down to form solid *gur*.

"The proportion of clean crystallized sugar (what is called *brown sugar* in England) which is obtained will, of course, vary somewhat with the nature of the *ráb* operated upon. In one of Messrs. Thomson and Mylne's experiments a yield of 40 per cent. was obtained, in another 52 per cent. In two experiments which I made 48·8 and 51·9 per cent. was obtained.

"The amount of *gur* obtained after boiling down the molasses seems to vary between 25 and 40 per 100 of *ráb* operated upon.

"The so-called 'turbine' or 'centrifugal' sugar is very fairly pure. I have analysed several samples, from which it appears that it contains from 90 to 95 per cent. of cane sugar, from ¾ to 2 per cent. of glucose, from ½ to 3 per cent. of moisture, from ¾ to 1¼ per cent. of mineral matter, and from 2 to 3 per cent. of other (organic) impurities.

"The *gur* obtained by boiling down the molasses is quite as good as much of the *gur* which is made by the cultivators direct from the juice. Judging by the composition of some samples which I have examined, it appears to have about the following composition :—Cane sugar from 65 to 80 per cent., glucose from 5 to 14 per cent., mineral matters from 3½ to .4 per cent., water and other impurities from 10 to 20 per cent.

"In addition to a regular trade which has sprung up in the Sháhabad District in 'centrifugal' sugar, which is exported long distances by rail, a similar trade has arisen in the *gur* made from the molasses. I believe that a great future exists for

this hand centrifugal machine, for it is clear that a very material economy in sugar must take place by its means over the native processes in which the greater part of the molasses becomes unfit for human consumption, and thus actually lost entirely, so far as food-supply is concerned.

"126. (7)—*The total amount of sugar in sugarcane and the amount remaining in the crushed refuse.*—Since it is obvious that by no process of simple crushing all the juice can be expressed from cane, it becomes an interesting question, how much is left with the refuse?

"The matter is of far greater importance than might at first sight appear. It has generally been assumed in India that everything related to the crushing process depends entirely on the mill, and the question of difference in the variety of cane has rarely, if ever, been considered.

"The first year's crushing of cane at the farms brought a very important fact to light. At Poona about 70 per cent. of juice was obtained from the cane there grown; at Cawnpore only about 50 per cent. was expressed. Since the mills which were used at the two places were essentially different, one might have said that the mills at Poona were infinitely better than those at Cawnpore. I knew, however, that such was not the case, some of the mills at Cawnpore having been of the very best workmanship and pattern.

"The difference between 50 and 70 per cent. of juice is so great that I decided to make some careful experiments in 1896 to find out what the true state of things really was. Accordingly, the total amount of sugar and of juice was determined in two lots of the Poona cane at Poona and in five different varieties grown at Cawnpore. The amount of juice expressed was also known, as well as amount of sugar in the latter, and the difference between the two gives the amount left in the crushed refuse cane.

"(It may be here mentioned that I found it impossible, for technical reasons, to determine the amount of sugar in the refuse *directly*. When working in the field out of reach of any laboratory, only certain appliances can be used, and I had therefore to be content with taking the *difference* figure above indicated as representing the quantity of sugar in the refuse.)

"The methods employed are sufficiently clearly set forth in paragraphs 11 to 13 of *Agricultural Ledger No. 19 of 1896*.

"The result of this investigation showed quite clearly on what factor depends the amount of juice which a good mill can express from sugarcane. The total amount of juice found in the two extreme cases examined varied from 85·2 to 91·5 per cent; the amount expressed from 45·4 to 72·2 per cent. A comparison of these figures throws no light on the subject, for there is obviously no simple relation between the two cases, in one 45 out of a total of 85 and in the other 72 out of 91 per cent. of juice.

"If, however, another item in the composition of cane, namely, the *fibre*, be brought into the comparison, and its effect be considered, the cause of these variations in the amount of juice expressed becomes evident.

"It will be readily understood that, so soon as cane is crushed up by the mill and the cells opened, the only physical force which prevents *all* the juice from running out is that of adhesion. The fibre of the cane becomes, in fact, a spongy material, and just as it is impossible to press all the water out of a wet sponge, so likewise is it impossible to express all the juice out of cane.

"But the analyses of the several varieties showed further that *quite independently of the variety* the *crushed* refuse cane contained approximately always the same amount of juice. At Poona the crushed cane consisted of 70 to 71 per cent. of juice and 29 to 30 per cent. fibre; at Cawnpore, with entirely different mills and other varieties of cane, the refuse consisted of 72 to 75 per cent. of juice and 25 to 28 per cent. of fibre.

"Thus the proportion of juice in the crushed cane remained approximately constant, *i.e.*, the fibre of these different varieties held approximately the same amount of juice in each case. Referring again now to the instances already alluded to, in one of which a cane contained 85 per cent. of juice and yielded only 45 per cent. at the mills, and in the other, the cane contained 91·5 per cent. juice and yielded 72 per cent. at the mills, if the amounts of crude fibre present in these canes be considered, its effect becomes apparent. The former contained 15 parts of fibre per 100 of fresh cane, and this 15 of fibre held 40 parts of juice, allowing only the other 45 parts to run out when pressed. In the second case, 100 parts contained 8·5 parts of fibre, and this 8·5 parts of fibre held 19·5 parts of juice, allowing the remaining 72·2 parts to run out when pressed. And, as a result of this investigation, it may be said that, even with the best of mills, each part of fibre in the fresh cane will hold twice to two and a half times its own weight of juice when pressed, and allow only the surplus to run out.

"It becomes, therefore, an all-important matter in the selection of varieties of cane to choose those which contain low proportions of crude fibre. Speaking generally of varieties, I have found it almost uniformly the case that the small varieties commonly grown for crushing purposes in the North-Western Provinces and Behar contain high proportions of crude fibre, and yield only some 50 to 55 per cent. of juice at the mills. On the other hand, the thick canes, some varieties of which are grown for chewing in the North-Western Provinces, others for crushing in Bengal and the Deccan, contain uniformly low proportions of crude fibre, and yield from 65 to 70 per cent. of juice at the mills.

"Thus, even assuming that the juice of the thin varieties is just as rich in sugar as that of the thick ones (and it is probable that it is not so rich), the introduction of thick varieties in place of thin ones would mean a direct gain in sugar production of about 25 to 30 per cent. over that at present obtained, and this without any further expenditure on manure, water, &c.

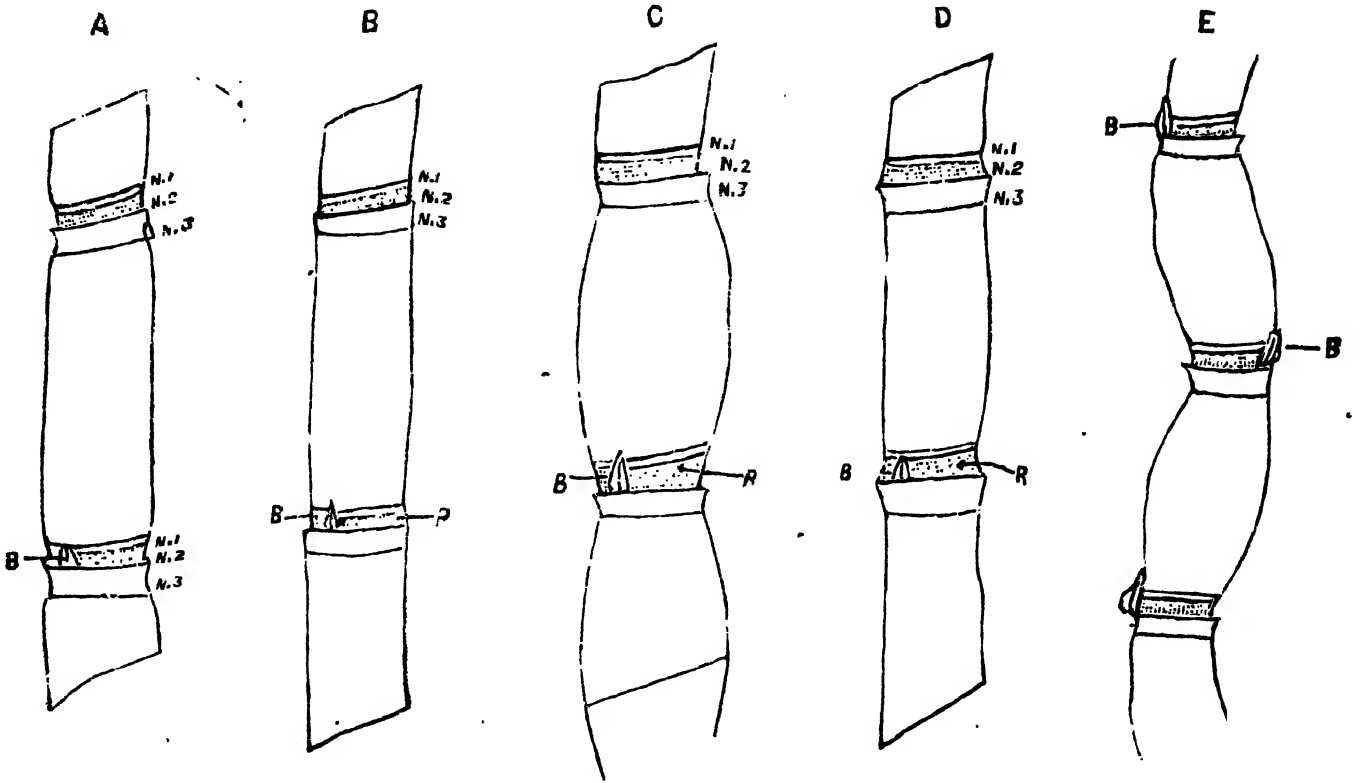
"127. (8)—*The amount of phosphoric acid and nitrogen in the sugarcane crop.*—At Poona the cultivators employ very large amounts of manure for this crop, and it has been further demonstrated by the field experiments that whilst it may be the case that these amounts are somewhat larger than necessary, very heavy dressings of manure *are* desirable, and will readily repay the initial cost. So far as one can draw any conclusion from the three years' experiments, it would appear that 500 lbs. of nitrogen per acre should be given in order to obtain a full crop. The amount of phosphoric acid required is still quite uncertain. Since it is necessary to apply such large amounts of manure, it seemed desirable to gain a knowledge of the amount of these plant-foods which are extracted from the soil by cane crops generally, and I made several determinations to this end. The cane, green tops, and dry leaves of crops at Cawnpore and Dâmraon were weighed, and portions of each submitted to analyses. The results obtained showed that in crops weighing 60,000 to 70,000 lbs. there was generally contained some 50 to 60 lbs. of nitrogen and the same amount of phosphoric acid. The crops at Poona are fully twice as heavy as this, and it may therefore be said that they remove 100 lbs. or more of each of these plant foods. There is consequently a considerable balance unaccounted for. I have examined the results of the analyses of the Poona (Mánjri) farm soils, and, judging by these, this balance of plant-food is still in the soil, and no material amount has been lost by drainage up to the present.

"128. *Concluding remarks.*—As to the general importance of experiments on the sugarcane crop, it is almost unnecessary for me to say anything. It is clear in the first place that so long as India has to import sugar (the net amount is about 75,000 tons annually), there is room for an increased production. It is also clear that, whilst an article of diet, which is common to the people generally, is imported, the cost of production is higher than it should be. But this is not all, for the greater part of the

sugar produced goes to the cities, and it thus becomes in a measure a luxury. Then, too, there is the difference between the outturn per acre as realised in the Deccan and Bengal on the one hand, where, with good varieties and good methods of cultivation, some 2½ to 4 tons of raw sugar is obtained, and in Behar and the North-Western Provinces on the other, where the outturn is certainly not more than 1 to 1½ tons per acre, and is often much less.

"As has been shown in the course of this section of my report, there is no need to go outside of India for good varieties, nor to other countries for good methods of cultivation. The best of varieties are met with; and the methods of cultivation in some parts are very perfect. What is wanted is the introduction of these good varieties and good methods into those parts, particularly the North-Western Provinces and Behar, which Provinces, it must be recollected, include much the largest area under cane of any Provinces of India."

DIAGRAM SHOWING DIFFERENT TYPES OF CANE.



B— Buds
R— Root dots
N1, N2, N3,—Nodes.

DESCRIPTION OF VARIETIES OF SUGARCANE.

(By Dr. Leather and Mr. Mollison.)

The following notes contain a description of a number of varieties of sugarcane which have been examined. It is possible that some of these are cultivated in other parts of India; doubtless also there are many other varieties which still remain to be described, and the writers think that the following introductory remarks will be of assistance to other agriculturists, not only in the recognition of varieties included in these notes and growing elsewhere, but that they will admit of descriptions of other varieties being reduced to a common standard. It must be stated, however, at the outset that, although among varieties of sugarcane each possesses particular markings or colours (to be presently dealt with in detail), there is usually in the case of any one particular variety considerable latitude within which appearances vary. For example, if a number of canes of the *madrási pounda* of the North-Western Provinces or the *puudia* of Poona or the *samsára* of Burdwan be examined, it can be at once seen that the colour varies in any of these varieties from green to straw yellow, but the colour may be modified, so that some canes may be almost entirely green, whilst in others some portions may be entirely yellow or the yellow may have an orange tinge. The latter tinge is particularly noticeable on canes growing on the headlands and, therefore, rather fully exposed to the sun. In the *madrási pounda* this orange yellow colour is sometimes the general colour of the whole cane. The same variety may vary in shape between the nodes; a cane may be generally of, say, type A (*vide diagram at page* 152), but some of the canes in the bundle may possess shape of type C more especially at the lower end; or, again, a cane may have grown in type E at one part (frequently the upper end), the remainder being straight.

Correspondingly great variations will be found among varieties in respect of other particulars, such as the extent to which aërial roots develope, the colour and shape of the rings at the nodes, &c.

At the same time each variety *is* distinct, and when canes of two varieties are placed together, the differences become much more apparent than if they are separately examined.

Occasionally no differences can be detected between the striped canes of two varieties. For example, the *mungo* and *bhurli* canes of Behar are so much alike that they are indistinguishable when stripped of the leaves; the leaves of the two are, however, quite distinct, those

of the *mungo* being of a paler green and inclined to crumple up; whilst those of the *bhurli* variety are darker in colour and remain flatter. Such a case is, however, in the experience of the writers, exceptional, and varieties, as a rule, are sufficiently distinct to enable one to recognize them without the leaves. In fact, the leaves are commonly of but little assistance in determining the variety.

In the following paragraphs the points which have been more particularly examined are dealt with in detail.

Colour. Sugarcane may be of the following colours :—

(1) Pale yellow or drab.
(2) Pale yellow and green.
(3) Nearly entirely green.
(4) Purple or purple red.
(5) Purple and yellow green in stripes.
(6) A more or less intimate mixture of dull purple and dull green, best described as a dirty colour.

Of these, however, only (4), (5) and (6) are really so distinct that the cane can be definitely said to belong to the one or the other. A striped cane, for instance, is always striped purple with yellow or yellow green. A cane that might be classed as wholly purple, when minutely examined, may or may not have longitudinal stripes of a darker or lighter colour, these being most distinctly marked on the upper internodes and only faintly marked on the lower. In purple canes the depth of colour may vary from very dark purple to a light reddish purple. It is at times practically impossible to decide whether a particular cane should be classed as pale yellow or drab, or pale yellow and green, and again it is hard to differentiate between pale yellow and green and nearly entirely green. It has been found that some varieties are almost or quite destitute of green in a certain field, *e.g.*, *betta kabbu* at Belgaum and *dhaur* and *rákra* in the North-Western Provinces ; but tinges of green are frequently found on the same variety when cultivated under other conditions, *e.g.*, *betta kabbu*, which at Poona had tinges of green on it. The same may be said of canes being all green. Sometimes a variety will be quite destitute of yellow in a certain field, but the same variety will be found in another field or locality to be quite yellow in places. For example, the *mungo* at Rosa was entirely green, whilst at Bára Banki it was partly yellow. The simplest plan is, therefore, to class all canes of a yellow or yellowish green or green colour together, and state the colour as found in a particular variety when examined.

Canes might then be divided into four classes as regards colour, namely:—

(1) Yellow or green or both.
(2) Purple.
(3) Purple and yellowish green in stripes.
(4) Purple and green mixed to form a dirty colour.

It not infrequently happens that a yellow green cane will have very distinct patches of red or pink upon it. Such, for example, is the *rámwie* of Sitápur District, North-Western Provinces. But this is quite distinct from the purple colour of canes belonging to classes 2 and 3.

Other points o colour.

In reference to the colour of canes, several other points are deserving of notice.

Very frequently patches or smudges of dirty black are found adhering to a cane. This is quite external, and may readily be rubbed off. It cannot be said that these smudges are characteristic ; they are found on some varieties, not on others, growing in the same field, and the origin of the smudges has not been determined. Then tinges of pink or red appear on some canes, especially just above the nodes where the leaf still adheres. This colour is not always on every cane of one variety in the same field, but is apparently a *common* characteristic on some varieties. For instance, the *rámwie* cane of the North-Western Provinces was tinged with pink at Sitápur (Oudh) and in one of the fields examined at Bára Banki (Oudh), but in another field of this variety at Bára Banki this colour was almost entirely absent.

Bloom.

There is on some varieties a mass of waxy bloom which covers the cane more or less, and the presence or absence of this bloom, as also the degree to which it covers a cane, seems to be quite characteristic of varieties.

General shape.

Sugarcanes have very characteristic shapes, some of the principal ones being depicted in the diagram on page 152 and shown as A, B, C, D and E. Of these the first three are perhaps the most common.

A—represents one which has distinct contraction at the nodes, but is otherwise a cane of practically uniform thickness.

B—represents a cane which is practically of uniform thickness throughout its length, there being no perceptible contraction or expansion at the nodes.

C—represents a cane which is contracted at the nodes, and becomes distinctly enlarged between the nodes.

D—represents one in which the nodes are distinctly larger than the cane, and it then becomes narrower between the nodes. This apparently is not a common shape.

Finally, E—represents a cane which has a zig-zag form from joint to joint.

Colour of nodes. The nodes of canes are very characteristically coloured or marked. There are always two bands—one immediately above the node marked N_2 in the diagram. This is about as broad as the buds are long *before they commence to grow*; also it is from this band that the roots develope either as aërial roots or when cane sets are planted. The little dots or growing points of the future roots are always perceptible. In some varieties they are much more distinct than in others. In fully mature canes the root dots of the lower nodes present a roughened appearance as if the roots had started to grow. At the upper nodes they present a smooth surface. The colour of the root dot band varies, but is generally lighter coloured than the main part of the cane. Immediately *below* the node is another band, marked N_3 in the diagram, of about the same breadth as the upper one. This band is generally of a grayish or bluish grey colour, occasioned partly by the coating of wax which is invariably present on this part of a cane, however little wax may be attached to other parts. The grey colour commonly terminates suddenly, thus making a very distinct band; it sometimes, however, extends downwards on the main part of the cane, and only gradually changes to the general colour of the cane. Such is the case, for example, on some canes of *hullu kabbu* of Belgaum.

Shape of band. The shapes of these two bands also vary. Sometimes the cane is contracted at both bands, but more commonly the contraction is only slight at the upper one, but considerable at the lower one. The different types of nodes are graphically represented in the diagram, of which A, B and C are very common. In addition to these, there is a ring marked N_1 in the diagram, which is common to many varieties, but almost, if not quite, absent in the case of others. The ring, if distinct, is about $\frac{1}{16}$" wide, and is commonly of a decided orange colour. Very frequently, however, it is not uniformly distinct in any one variety, and not of uniform width or prominence on all the nodes of the same variety.

Buds. The buds vary in shape, size and colour among varieties, but since their shape and colour vary according to whether they have commenced to grow or not, care must be taken to notice this point in examining them. At the same time on some varieties

(if not over ripe) they are uniformly rounded or oval, whilst in the case of others they are more pointed. In some varieties the scale-like covering which protects the buds is coarse and fibrous in texture; in others it is smooth, thin and shining.

Root dots.

Regarding the little dots indicating the seat of the growing point of the future root, not much need be said. They are distinct on some varieties, but only just perceptible on others.

Aërial roots.

Sugarcanes have a general tendency to throw out aërial roots *from the nodes which are near the ground*, but some varieties produce them, not only close to the ground, but for some distance up the cane. Occasionally this is a very pronounced characteristic. For example, the *Sháháranpuri* and the *madrási* or *madrási pounda* of the North-Western Provinces and the *samsára* of Bengal frequently produces them over its entire length, and, moreover, the aërial roots of one node grow towards and join those of the next node.

Girth.

The girth of canes varies apparently, not only between varieties, but also according to the perfection of growth of the variety. Generally, however, it may be said that the girth of a thin specimen of any one variety will not be less than ⅓th of that of a really good specimen of that variety. For this reason the girth of a cane is a most important consideration. If an unknown variety has a general thickness of 2″, but is similar in other points to one having a general girth of 4″, it may be said with certainty that they are different varieties. The girth of some varieties is almost uniform throughout the entire length. On the other hand, sometimes canes are thinner at the top end than at the bottom, and less frequently they are thinner at both ends than in the middle.

Length between nodes.

The length between the nodes of a cane varies *very* considerably, but nevertheless well grown canes of all varieties appear to be characterised more or less in this particular.

The *hullu kabbu* of Belgaum, for example, has generally long inter-nodes, whilst the *betta kabbu* of Belgaum has frequently short ones. The *malabári* cane of Surat has generally long inter-nodes. The *meva* cane of the same district has invariably short inter-nodes. If a crop of cane of any variety is stunted in growth for want of manure or any other cause, the internodes are invariably short.

General remarks.

But although such broad distinctions as the above may be made between canes generally, it is not always easy to decide to which variety a cane belongs. The shape of canes and their colours merge in a measure the one into the other.

In the case of colour, any cane may be easily placed under one of the four groups which have been suggested; but in the case of the colour and distinctness of the bands of the nodes, whether the ring (marked N_1 in the diagram) is distinct or not, whether a cane is enlarged or contracted between the nodes, &c., whether aërial roots are common to a variety, what the shape of the buds is, &c., &c., it is frequently difficult to say positively what would be an accurate description for any one variety. Nevertheless, if, in describing canes, the various points be noted on the above indicated lines, descriptions given by different persons of the same variety would probably agree more completely than if such descriptions were referred to no general standard.

Vernacular names.

That the cultivators can recognise the varieties of their particular district there is not the least doubt, and if they all spoke the same tongue, the recognition of the many varieties grown in India would be a very simple matter. Unfortunately, the names given by the people are not always of much value.

In the North-Western Provinces and Oudh not much difficulty has been experienced in this respect.

In the Southern Marátha Country, however, much confusion exists among the names, as the following instances will show. There are three thick canes grown, one being a green yellow cane (the *pundia* of Poona), a second is entirely purple, and the third is striped purple and yellow green.

The *pundia* is called *pundia* throughout the Southern Marátha Country, but it is also called *bile kabbu* (*i.e.*, white cane) and *rasdáli kabbu* at Dhárwár. The purple cane is generally called *káre kabbu*, but is also called *rasála kabbu* in some villages. The striped cane is called *rasála*, *rasáli*, *rasváli* or *rámrasdáli*.

When one enquires into the meaning of these words, the cause of the confusion becomes apparent. *Bile* means "white," and is doubtless applied by the people to that variety of the three which is yellowish green in colour (that is, lightest in colour) to distinguish it from the purple ones.

Rasála or *rasvála* or *rasdáli*, all of which are probably the same words differently pronounced, means juicy, and the term is applied to all the three varieties, because they are more juicy than the thin varieties also grown in the Southern Marátha Country.

In the name *rámrasdáli*, the prefix *rám* is derived from *rám* = God, and is probably applied to the striped cane, because it is the prettiest of the three.

In finding the different varieties of cane in a district, the cultivators have been found of the greatest assistance to the writers; they

will readily indicate the fields in which the different varieties are grown, and the measurements and other descriptive remarks may then be made without any trouble.

The foregoing has only reference to the appearance and size of canes. It remains to say a word with regard to the juice. Juice of canes.

The percentage of juice obtainable in the iron mill from any variety is apparently fairly constant. (*Vide*, for example, the varieties grown at Belgaum and Dhárwár described further on.)

So far as the experience of the writers goes, thick canes will give from 68 to 72 per cent., while from thin ones only 50 to 60 per cent. will be obtained. Consequently, it is most important to find out if this rule may be relied upon. The subject is dealt with more fully in *Agricultural Ledger No. 19 of 1896* at pages 18 to 20. The proportion of juice extractable may be readily determined by passing about 100 lbs. of cleaned cane of any one variety through an iron mill and weighing the *juice* obtained. The percentage of sugar in the juice can be approximately determined from the specific gravity, and this subject has been dealt with in a special paper on the chemical composition of sugarcane. (*Agricultural Ledger Series No. 3 of 1897.*)

DETAILED DESCRIPTION OF DIFFERENT VARIETIES OF SUGARCANE.

Varieties examined.

(A).—Bombay Presidency Varieties.

(*Examined by* Mr. Mollison.)

Variety—*Khajuria* or *meva*.

Where grown—Surat District. Khajuria or meva.

General appearance—A yellow green cane of medium thickness; tall and fairly soft; used only for raw eating; tillers freely; ratoons well; grows in clumps.

Type—C; inter-nodes only slightly bulged.

Bloom—A little.

Nodes—Ring N_1—Not distinct.

Band N_2—Irregular in shape; yellow or cream colour; root dots well marked.

Band N_3—Well defined; blue grey colour.

Height—About 6 feet without tops when well grown.

Girth—$3\frac{1}{4}$" to $3\frac{3}{4}$"; almost uniform from root to top.

Inter-nodes—$2\frac{1}{2}$ to 3 inches; characteristically short.

Aerial roots—On three or four nodes near root only.

Buds—Very prominent; rounded; sharp point; covered with shining scale-like covering, except on lower nodes, where the covering is brown and fibrous.

Dr. Leather's *Analysis*—

	Poona Farm Crop. 1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)
Percentage of juice to cane ...	59·15	67·25
Do. of sugar to juice ...	10·98	14·80
Do. of glucose in juice ...	1·40	1·00

Malabári.

Variety—Malabári.

Where grown—Surat District.

General appearance—A fairly thick, tall, soft cane; yellow green colour; cane generally somewhat bent at top end; does not ratoon well.

Type—C; inter-nodes fairly bulged.

Bloom—Very little.

Nodes—Ring N_1—Indistinct on lower nodes; fairly well marked on upper nodes; pale yellow and green; root dots well marked.

Band N_2—Yellow and green; root dots well marked.

Band N_3—Light, blue-grey colour.

Height—$7\frac{1}{2}$ to 9 feet without tops when well grown.

Girth—4″ to $4\frac{3}{4}$″.

Inter-nodes—$3\frac{1}{2}$″ to $5\frac{1}{2}$″.

Aerial roots—On three or four lower nodes only.

Buds—Very small; covered with fibrous dull brown covering.

Vánsi or bamboo; betta kabbu.

Variety—Vánsi or bamboo, same as *betta kabbu* of Southern Marátha Country.

Where grown—Surat and Belgaum Districts.

General appearance—A cream coloured or light yellow cane; vertically scored with black or brown lines; very tall; thin and hard; of uniform thickness throughout; the leaves are narrow and long, and the dried dead leaves enclose the cane, and thus protect it from damage by jackals and pigs.

Type—B.

Bloom—Good deal; black patches numerous.

Nodes—Ring N_1—Distinct dull yellow colour.

Band N_2—Regular in width; cream colour; root dots not numerous and not distinctly marked.

Band N_3—Not well marked; light grey colour; sometimes nearly white.

Height—Without tops 8 feet; some canes 10 feet long when wel grown.

Girth—2½″ to 3¾″.
Inter-nodes—3½″ to 5″.
Aerial roots—On four to six lower nodes.
Buds—Rounded; small; not prominent; shining light green scale covering on upper and brown or *kháki* scales on lower buds.
Dr. Leather's *Analysis*—

	Belgaum Crop (*betta kabbu*).	Poona Farm Crop (bamboo or *vánsi*).	
	1896.	1896.	1897.
	(Local).	(Fresh Imports.)	(Acclimatized 1 year.)
Precentage of juice to cane ...	60·00	57·70	59·09
Do. of sugar to juice ...	12·64	9·53	14·50
Do. of glucose in juice...	0·95	1·54	1·00

Variety—*Bhuri.* Bhuri.
Where grown—Surat District.
General appearance—A fairly tall, moderately thick, hard cane; the colour varies between the lower and upper inter-nodes considerably; the lower ones are a dirty looking admixture of brown, dull purple, and dull green; the upper nodes are dull purple, mixed with a good deal of dull green; the canes are mostly scored or blotched with grey.
Type—E; only slightly zig-zag in shape.
Nodes—Ring N_1—Not very distinctly marked.
Band N_2—Not distinctly marked, but varies with the cane in colour between upper and lower nodes; root dots very prominent.
Band N_3—Hardly observable in lower nodes; a ring of grey bloom on upper nodes.
Height—Without tops 6 to 7 feet when well grown.
Girth—3½″ to 3¾″.
Inter-nodes—3½″ to 4½″.
Buds—Fairly large; flattened; pointed; covered with fibrous *kháki* coloured scales.
Aerial roots—On lower nodes.

Variety—*Phojbhuri.* Phojbhuri.
Where grown—Surat District.
General appearance—Very like *bhuri* in appearance, excepting that the colour is yellow green on upper inter-nodes, but irregularly tinged here and there, with brown and purple on lower inter-nodes.
Type—E; only slightly zig-zag in shape.
Bloom—A little.

Nodes—Ring N_1—Faintly marked.

Band N_2—Irregular in width; yellow or green in colour; root dots fairly distinctly marked.

Band N_3—Faintly marked on lower nodes, but more distinctly on upper ones; blue grey colour.

Height—6 to 7 feet when well grown.

Girth—$3\frac{1}{2}$" to 4".

Inter-nodes—$3\frac{1}{2}$" to $4\frac{1}{2}$".

Buds—Medium size; flat; pointed; covered with *kháki* coloured scales.

Aerial roots—On lower nodes.

Songadi.

Variety—*Songadi.*

Where grown—Surat District.

General appearance—A dull purple, mixed with dull green; scored irregularly with *kháki* coloured marks; this cane is tall, hard, and nearly of uniform thickness throughout the whole length.

Type—E.

Bloom—None.

Nodes—Ring N_1—Very wide and irregular in shape; varies in colour, generally purple.

Band N_2—Irregular in shape and colour; root dots distinct and lighter in colour; thin band.

Band N_3—Regular in shape, but varies in colour throughout the length of the cane in a very erratic manner.

Height—8 to 10 feet without tops when well grown.

Girth—$3\frac{1}{2}$" to 4".

Inter-nodes—5" to 6".

Aërial roots—On lower nodes only.

Buds—Fairly large, flat, pointed, and *kháki* coloured.

Káli jádi.

Variety—*Káli jádi.*

Where grown—Surat District.

General appearance—A tall, hard cane of almost uniform thickness from root to top; dull purple in colour; scored and blotched with *kháki* colour.

Type—E; but internodes only slightly zig-zag.

Bloom—A little.

Nodes—Ring N_1—Indistinct on lower nodes; distinct and yellow green colour on upper nodes.

Band N_2—Purple with faintly marked root dots on lower nodes; pale green on upper nodes.

Band N_3—Distinct band of blue grey bloom.

Height—6 to 7 feet when well grown.
Girth—$3\frac{1}{2}$" to 4".
Inter-nodes—4" to $4\frac{1}{2}$".
Aerial roots—Very few.
Buds—Small, flat, blunt, and *kháki* coloured.

Deogadi.

Variety—*Deogadi*.
Where grown—Ratnágiri District.
General appearance—A very tall, straight, fairly thick cane; moderately hard; smooth; yellow and pale green in colour.
Type—A; inter-nodes very slightly bulged.
Bloom—Very slight.
Nodes—Ring N_1—Distinctly marked; very regular in width; narrow; varies in colour, mostly deep yellow.
Band N_2—Very regular; distinctly marked; green yellow in colour; root dots numerous and very distinct.
Band N_3—Grey blue in colour and very distinct.
Height—7 to 8 feet without tops; very well grown canes over 10 feet without tops.
Girth—$3\frac{1}{2}$" to $4\frac{1}{4}$"; middle inter-nodes slightly thicker than lower and upper ones.
Inter-nodes—$3\frac{1}{2}$" to $5\frac{1}{2}$".
Aerial roots—None.
Buds—Small, rounded, fairly sharp points; covered with a shining scale covering; varies in colour.
Dr. Leather's *Analysis*—

	Poona Farm Crop.	
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)
Percentage of juice to cane ...	70·50	68·0
Do. of sugar to juice ...	11·46	14·9
Do. of glucose in juice...	1·87	0·9

Máhim yellow-green; *pundia*.

Variety—*Máhim yellow-green*; same as Poona *pundia* and *pundia* of Belgaum, &c.
Where grown—Máhim, Thána District.
General appearance—A thick, soft, tall cane, tapering to small inter-nodes at the top; yellow green in colour; cane generally bent or crooked.
Type—C; inter-nodes bulged considerably, especially at the top end; cane much inclined to crack vertically before ripening like all soft thick varieties; ratoons well.
Bloom—Good deal.

Nodes—Ring N_1—Irregular; not particularly noticeable; orange.
Band N_2—Wide and irregular in shape; yellow or yellowish green; root dots numerous and easily seen.
Band N_3—Wide; distinct; blue-grey in colour.

Height—7½ to 9 feet without tops; some canes 10 feet long.

Girth—4½″ to 5″.

Inter-nodes—3½″ to 5″.

Aerial roots—Few or none.

Buds—Rounded, prominent, moderate in size; covered with dull brown or *kháki* fibrous covering.

Dr. Leather's *Analysis*—

	Poona Farm Crop. (Máhim Yellow green.)		(*Pundia*)	Belgaum Crop. (*Pundia.*)
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)	1896. (Local.)	1896. (Local.)
Percentage of juice to cane ...	71·00	70·58	68 to 73	68 to 73
Do. of sugar to juice ...	12·38	14·80	16 to 17·4	13·71 to 17·49
Do. of glucose in juice..	1·87	0·80	1·2 to 1·6	0·83 to 1·57

Green Mauritius.

Variety—*Green Mauritius.*

Where grown—Imported in 1893 by the Bombay Agricultural Department.

General appearance—A tall, moderately thick, fairly hard cane; lower inter-nodes green; colour changes gradually towards the top to a pale yellow tinged with green; cane flowers freely and inclined to produce side shoots prematurely; it tillers and ratoons well.

Type—A.

Bloom—None.

Nodes—Ring N_1—Well marked; rather wide; much the same colour as the cane.
Band N_2—Mostly pale yellow, tinged with green; regular in width; root dots fairly well marked.
Band N_3—Distinct; light blue grey in colour.

Height—7 to 7½ feet without tops.

Girth—3½″ to 4″.

Inter-nodes—3½″ to 4½″.

Aerial roots—Few or none.

Buds—Round; fairly prominent slightly pointed; covered by a light *kháki* fibrous covering.

Dr. Leather's *Analysis*—

	Poona Farm Crop. 1896.	1897.
Percentage of juice to cane... ...	65·70	68·75
Do. of sugar to juice ...	14·71	14·10
Do. of glucose in juice ...	0·99	1·40

Rasdáli; ras váli; rasáli.

Variety—*Rasdáli* ; *rasváli* ; *rasáli* ; that is, juicy.
Where grown—Haliyál, Kánara District.
General appearance—A tall, fairly hard, yellow green cane of moderate thickness.
Type—A.
Bloom—Little or none.
Nodes—Ring N_1—Distinct ; narrow ; varies in colour ; mostly green or yellow.
Band N_2—Wide ; fairly regular in width ; root dots numerous and distinct.
Band N_3—Wide ; distinct ; blue grey in colour.
Height—7 to 7½ feet without tops when well grown.
Girth—3¼″ to 3¾″.
Inter-nodes—5″ to 6″.
Buds—Small; prominent ; rounded ; covered by brown or *kháki* scales.
Dr. Leather's *Analysis*—.

	Poona Farm Crop. 1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)
Percentage of juice to cane	60·40	62·14
Do. of sugar to juice	13·18	15·30
Do. of glucose in juice ...	1·49	1·00

Yellow green.

Variety—*Yellow green.*
Where grown—Bijápur, Bágalkot, Bijápur District.
General appearance—A yellow green cane ; fair in length and thickness ; slightly scored with brown ; lower inter-nodes not so thick as those in middle of cane.
Type—A, sometimes C ; internodes very slightly bulged.
Bloom—A little.
Nodes—Ring N_1—Distinctly marked in upper nodes, but not so distinct on the lower ones ; varies in colour, but commonly part of ring bright brown.
Band N_2—Distinctly marked ; pale green and yellow in colour ; root dots very distinctly marked.
Band N_3—Very distinct and regular ; of blue grey colour.
Height—8 to 8½ feet without tops when well grown.
Girth—4″ to 4½″.
Inter-nodes—Very regular, in length 4½″ to 5″.
Aerial roots—None.
Buds—Small ; rounded ; pointed ; covered with *kháki* coloured scales.

Dr. Leather's *Analysis*—

	Poona Farm Crop. (Bijápur Yellow green.)		(Bágalkot Yellow green.)	
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)
Percentage of juice to cane ...	70·40	70·62	68·40	68·75
Do. of sugar to juice ...	14·30	16·60	12·34	16·20
Do. of glucose in juice ...	1·57	1·10	1·94	1·40

Hullu kabbu.

Variety—*Hullu kabbu* (*hullu* = grass and *kabbu* = sugarcane).

Where grown—Southern Marátha Country.

General appearance—A very thin, tall, hard cane; yellow green in colour; generally bent towards the top; many dirty patches; cane securely enclosed in dead side leaves; tillers freely; ratoons well.

Type—Generally B.

Bloom—Good deal.

Nodes—Ring N_1—Orange yellow, tinged with green on upper nodes.

Band N_2—Dull yellow; root dots distinct.

Band N_3—Grey.

Height—7 to 8 feet; some canes 10 feet without tops when well grown.

Girth—$1\frac{3}{4}''$ to $2''$.

Inter-nodes—5" to 7".

Aerial roots—A few on lower nodes only.

Buds—Slightly prominent; elliptical; lower buds covered by brown scales; upper ones light green in colour.

Dr. Leather's *Analysis*—

	Poona Farm Crop.		Belgaum Crop.
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)	1896. (Local.)
Percentage of juice to cane ...	52·60	56·17	55·90 to 59·80
Do. of sugar to juice ...	16·06	16·90	14·27 to 14·92
Do. of glucose in juice ...	A trace only.	0·70	A trace to 0·74

Yellow-green.

Variety—*Yellow-green.*

Where grown—Ránebennur, Dhárwár District; and Chikodi, Belgaum District.

General appearance—A light green or yellow cane; moderately thick; fairly tall and soft.

Type—A, sometimes C; inter-nodes slightly bulged; nodes not prominent.

Bloom—Some.

Nodes—Ring N_1—Distinctly marked; narrow; dull orange brown in colour, which, however, varies in lower nodes.

Band N_2—Distinctly marked; wide; root dots distinct and numerous.

Band N_3—Distinct; wide; dull grey in colour.

Height—6½ to 7 feet without tops when well grown.

Girth—3″ to 4″.

Inter-nodes—3″ to 5″.

Aerial roots—None.

Buds—Small; round or oval; blunt; covered by dull *kháki* scale-like covering, which gets fibrous on lower buds.

Dr. Leather's *Analysis*—

	Poona Farm Crop.		
	(*Chikodi* Yellow-green.)		(Ránebennur Cane.)
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)	1896. (Fresh Imports.)
Percentage of juice to cane ...	65·50	68·47	64·10
Do. of sugar to juice ...	11·35	14·90	12·04
Do. of glucose in juice..	1·80	1·90	1·48

Sanna bile kabbu.

Variety—*Sanna bile kabbu* (*sanna* = small, *bile* = white, *kabbu* = sugarcane).

Where grown—Khánápura, Belgaum District; Southern Maratha Country.

General appearance—A tall, straight yellow cane, tinged irregularly with pale green with vertical red brown scores on lower end; characteristic bright orange red colouring on leaf sheaths of upper leaves; dry leaves closely enclose the cane: many dirty patches on cane; tillers freely and ratoons well.

Type—B.

Bloom—A little.

Nodes—Ring N_1—Very distinct; deep yellow; fairly narrow.

Band N_2—Cream colour, well marked; root dots fairly distinct.

Band N_3—Distinct; light blue grey colour.

Height—8½ to 10 feet without tops when well grown.

Girth—3¼″ to 4″; uniform.

Inter-nodes—4″ to 4½″.

Aërial roots—Hardly any.

Buds—Small, rounded, and prominent; lower buds *kháki* coloured; upper buds pale yellow and green.

Dr. Leather's *Analysis*—

	Poona Farm Crop.		Khánápur Crop.
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)	1896. (Local.)
Percentage of juice to cane	60·00	58·20	58·29
Do. of sugar to juice	17·38	16·00	13·31
Do. of glucose in juice ...	0·68	0·90	1·09

Red or purple Mauritius.

Variety—*Red* or *purple Mauritius.*

Where grown—Imported in 1893 by the Bombay Agricultural Department.

General appearance—A tall, thick, hard cane; general colour purple or bright purple on lower inter-nodes; the colouring gets lighter and brighter towards the upper inter-nodes; distinct, almost black, vertical stripes in most of the inter-nodes resembling streaked cane; the cane has a shining appearance; leaves sometimes variegated in colour; tillers freely; inclined to flower, also to produce side shoots prematurely.

Type—A.

Bloom—None.

Nodes—Ring N_1—Very distinct and, except in lower nodes, of cream colour.

Band N_2—Colour variable, but always lighter than the general colour of the cane; mostly dull yellow, irregularly tinged with red or purple; root dots very distinct; each dot surrounded by a light coloured circle.

Band N_3—Very distinct; dull blue grey in colour.

Height—8 to 9 feet without tops.

Girth—4″ to 4½″; uniform.

Inter-nodes—4½″ to 6″.

Aerial roots—Few or none.

Buds—Small; round; covered by a shining scale covering; light colour on the upper nodes and dull purple on the lower one.

Dr. Leather's *Analysis*—

	Poona Farm Crop.	
	1896.	1897.
Percentage of juice to cane	66·75	65·47
Do. of sugar to juice	12·88	12·50
Do. of glucose in juice	1·64	1·20

Purple cane.

Variety—*Purple cane.*

Where grown—Bijápur District; Bassein, Thána District.

General appearance—A fairly tall and moderately thick cane; lower inter-nodes dull purple, irregularly scored vertically with dull *kháki* colour; upper inter-nodes lighter in colour, with a streaked appearance; slightly resembling streaked cane.

Type—E.

Bloom—None.

Nodes—Ring N_1—Indistinct; of variable colour; upper nodes pale yellow; lower ones dull purple.

Band N_2—Pale yellow in upper nodes; pale dull and brown and purple in lower ones.

Band N_3—Very distinct; light blue grey in colour.

Height—7 to 8 feet without tops when well grown.

Girth—$3\frac{1}{2}''$ to $4''$; lower inter-nodes considerably smaller in diameter than the middle ones.

Inter-nodes—$3\frac{1}{2}''$ to $5''$.

Aerial roots—Very few or none.

Buds—Narrow; long; pointed; covered with fibrous scale-like covering; upper buds inclined to shoot early.

Dr. Leather's *Analysis*—

	Poona Farm Crop. (Bijápur Purple Cane.)		(Bassein Purple Cane.)	
	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)	1896. (Fresh Imports.)	1897. (Acclimatized 1 year.)
Percentage of juice to cane ...	63·00	62·50	57·10	64·80
Do. of sugar to juice ...	13·27	13·80	13·31	13·60
Do. of glucose in juice..	1·33	1·00	1·32	1·70

Variety—*Káre kabbu* (*káre* = black, *kabbu* = sugarcane). Káre kabbu.

Where grown—Belgaum, Khánápur, Belgaum District; Ránebennur, Dhárwár District.

General appearance—A dark purple cane of fair length and moderately thick; the general colour is tinged with green towards top, where cane is immature; ratoons fairly well.

Type—E, but only slightly zig-zag.

Bloom—None.

Nodes—Ring N_1—Distinct; varies in colour similarly to Band N_2.

Band N_2—Light purple or yellow green at upper end of cane; purple at lower end; root dots distinct.

Band N_3—Blue grey.

Height—6 to $7\frac{1}{2}$ feet without tops when well grown.

Girth—$3\frac{1}{4}''$ to $3\frac{3}{4}''$.

Inter-nodes—$3''$ to $4''$.

Buds—Dull *khákí* or light brown in colour; medium in size; oval.

Dr. Leather's *Analysis*

	Poona Farm Crop. (Belgaum Cane.) 1896.	Poona Farm Crop. (Khánápur Cane.) 1896.	Poona Farm Crop. (Ránebennur Cane.) 1896.	Belgaum, Khánápur and Ránebennur Crop. (Local.) 1896.
Percentage of juice to cane ...	60·70	63·00	54·40	60·70 to 66·00
Do. of sugar to juice ...	11·67	6·13	10·27	13·32 to 16·67
Do. of glucose in juice...	1·54	2·57	1·60	0·85 to 1·17

Rámrasdáli.

Variety—Rámrasdáli.

Where grown—Haliyál, Kánara District.

General appearance—A fairly tall soft cane; uniform in thickness; irregularly streaked with dull purple and pale green streaks, varying very irregularly in width; ratoons fairly well.

Type—A and E combined; only slightly zig-zag; inter-nodes slightly bulged sometimes.

Bloom—A little.

Nodes—Ring N_1—Fairly distinct; varies in colour.

Band N_2—Regular in shape; not distinctly marked; root dots fairly distinct.

Band N_3—Distinct; light blue grey in colour.

Height—7 to 8 feet without tops.

Girth—3¼″ to 4″; regular throughout.

Inter-nodes—5″ to 7″.

Aerial roots—None or few.

Buds—Fair sized; rounded pointed; covered by fibrous brown scales.

Dr. Leather's *Analysis*—

	Poona Farm Crop. 1896. (Fresh Imports.)	Poona Farm Crop. 1897. (Acclimatized 1 year.)
Percentage of juice to cane	70·10	63·70
Do. of sugar to juice	8·22	14·50
Do. of glucose in juice	2·41	0·80

Streaked cane.

-Streaked cane.

Where grown—Gadag, Dhárwár District; also Belgaum and Khánápur, Belgaum District.

General appearance—A tall, thick, soft cane; irregularly streaked in purple and green or pale purple and yellow colours; streaks not so distinct as in *rámrasdáli.*

Type—C and E combined; but inter-nodes only slightly bulged and cane only slightly zig-zag in appearance.

Bloom—Good deal.

Nodes—Ring N_1—Fairly well marked; varying in colour; upper nodes yellow; lower nodes irregular in colour.

Band N_2—Irregular; also varies in colour; root dots very distinct, but small.

Band N_3—Distinct; light blue-grey coloured.

Height—7 to 8 feet without tops.

Girth—4″ to 4½″; thick canes 5″.

Internodes—4″ to 5″; lower internodes slightly smaller in diameter than the middle ones.

Aerial roots—None.

Buds—Fairly large; pointed; prominent; covered with *khâki*-coloured scales.

Dr. Leather's *Analysis*—

	Poona Farm Crop. (Streaked Cane from Gadag.) 1896. (Fresh Imports.)	Poona Farm Crop. (Streaked Cane from Gadag.) 1897. (Acclimatized 1 year.)	Belgaum, Khánápur, and Gadag Crop. (Local.) 1896.
Percentage of juice to cane ...	70·20	69·86	71
Do. of sugar to juice ...	8·87	14·50	14·55 to 17·37
Do. of glucose in juice..	2·12	0·50	0·79 to 1·39

(B.)—Varieties outside the Bombay Presidency.

(*Examined by* Dr. Leather.)

Variety—*Madrási pounda.* Madrási pounda.

Where grown—Sitápur; Bára Banki; Bareilly.

General appearance—A thick, orange-yellow to green straight cane; this is a very erect strong cane, harder outside than most *poundas*; little liable to crack lengthwise or to fall down; it gives about 70 per cent. of juice, and has about 15 to 16 per cent. of sugar in the juice (*vide* Cawnpore Farm Experiments).

Type—A, frequently C.

Bloom—None.

Nodes—Ring N_1—Generally indistinct or absent.

Band N_2—Drab or green; root dots prominent.

Band N_3—Distinct; gray coloured.

Height—5 to 8 feet.

Girth—4″ to 4¾″.

Internodes—3½″ to 5″.

Aerial roots—Common; they grow from one node to the other like the Sháháranpuri *pounda*.

Dry leaves—Generally open out.

Samsára.

Variety—*Samsára.*

Where grown—Dumraon ; Burdwan.

General appearance—A yellow green cane ; frequently lemon yellow, or orange coloured where exposed to sunlight; erect.

Type—C, sometimes A.

Bloom—Very little ; no scorings.

Nodes—Ring N_1—Narrow ; indistinct.

Band N_2—Orange or yellow-green ; root dots distinct.

Band N_3—Well defined ; gray.

Height—4 to 6 feet at Dumraon ; 8 to 12 feet at Burdwan.

Girth—$3\frac{1}{2}''$ to $4''$.

Internodes—$3\frac{1}{2}''$ to $4\frac{1}{2}''$.

Aerial roots—Many ; they grow from one node to the next below in a very characteristic manner.

Buds—Large ; groove narrow deep.

Dry leaves—Open out from cane.

Dr. Leather's *Analysis*—

	Dumraon Farm Crop. Castor-cake Plot.	Cattle-dung Plot.	Burdwan Farm Crop. Castor-cake Plot.	Cattle-dung Plot.	Village Kantal-gachi.	Village Bampata.	Village Hartsimal.
Percentage of juice to cane	...	...	...	...	71·89	73·20	67·70
Percentage of sugar to juice	12·35	15·36	14·24	14·24	15·24	15·24	15·24
Percentage of glucose in juice...	1·34	0·72	1·86	1·86	1·86	1·86	1·86
Specific gravity at 15·5° C.	1,067	1,074	1,075	1,075	1,079	1,078	1,078

Sháháranpuri.

Variety—*Sháháranpuri.*

Where grown—Cawnpore and Bareilly.

General appearance—Yellow green coloured ; straight ; generally free from black patches at Cawnpore, but some patches found at Bareilly.

Type—Generally C, less frequently A.

Bloom—A little.

Nodes—Ring N_1—Indistinct ; green.

Band N_2—Orange coloured ; root dots very distinct.

Band N_3—Blue gray.

Buds—Very liable to shoot.

Height—4 to 6 feet.

Girth—$3\frac{1}{4}''$ to $4''$.

Internodes—$2''$ to $3''$; sometimes $5''$.

Aerial roots—Very frequent throughout the whole length of cane, and grow from one node to the other.

Dry leaves—Open out and expose the cane.

Dr. Leather's *Analysis*—

	Cawnpore Crop.	Bareilly Crop.
Percentage of sugar to juice ...	13·54	14·32
Percentage of glucose in juice ...	0·67	0·37
Specific gravity at 15·5° C. ...	1,066	1,070

Kájli.

Variety—*Kájli.*

Where grown—Burdwan.

General appearance—A purple cane; straight.

Type—A or D.

Bloom—Good deal.

Nodes—Ring N_1—Indistinct; yellow or purple.

Band N_2— Generally yellow on upper part; purple on lower end; root dots prominent.

Band N_3—Distinct; gray.

Height—6 to 8 feet.

Girth—3″.

Internodes—3″ to 3½″.

Aerial roots—Many; half-way up the cane.

Dr. Leather's *Analysis*—

	Village Hartsimal.	Village Kantalgachi.	Village Banpata.
Percentage of juice to cane ...	66·00	68·10	68·00
Do. of sugar to juice ...	17·05	17·05	17·05
Do. of *gur* to cane ...	13·00	13·0	13·00
Do. of glucose in juice	1·54	1·54	1·54
Specific gravity at 15·5° C. ..	1,083	1,080	1,080

Purple pounda.

Variety—*Purple pounda.*

Where grown—Bára Banki; Bareilly.

General appearance—Sometimes reddish purple, sometimes very dark purple.

Bloom—Only on the Band N_3 below the nodes.

Height—5 to 7 feet.

Girth—3½″ to 4½″.

Internodes—3″ to 4½″.

Aerial roots—Sometimes at lower end.

Dry leaves—Fall off.

Mungo.

Variety—*Mungo.*

Where grown—Dumraon.

General appearance—Yellow green coloured; straight; seldom scored and with no black patches; very like *bhurli*, but the leaves are of lighter green colour, and are soft and crumpled up.

Type—B.

Bloom—Much.

Nodes—Ring N_1—Indistinct and drab.
Band N_2—Drab; root dots not very distinct.
Band N_3—Indistinct.
Height—5 to 7 feet.
Girth—2″ to $2\frac{1}{2}$″.
Internodes—$3\frac{3}{4}$″ to $4\frac{1}{2}$″.
Aerial roots—None.
Buds—Small.
Dry leaves—Remain folded.
Dr. Leather's *Analysis*—

	Dumraon Farm Crop, 1897. Castor-cake Plot.	Cattle-dung Plot.
Percentage of sugar to juice	11·73	13·53
Do. of glucose in juice... ...	1·18	0·46
Specific gravity at 15·5° C.	1,058	1,064

Bhurli.

Variety—*Bhurli.*
Where grown—Dumraon.
General appearance—A short yellow green coloured cane; straight and of uniform thickness; black patches infrequent; scoring infrequent; very like *mungo*; the canes of these two varieties are almost indistinguishable, but the green leaves are quite distinct; those of *bhurli* are deeper green and not soft and crumpled up like those of *mungo.*
Type—B.
Bloom—Considerable.
Nodes—Ring N_1—Indistinct; drab.
Band N_2—Drab; green; root dots distinct.
Band N_3—Indistinct; gray.
Height—4 to 6 feet.
Girth—2″ to $2\frac{3}{4}$″.
Internodes—$3\frac{1}{2}$″.
Aerial roots—None.
Dry leaves—Sometimes open out; sometimes remain folded.
Dr. Leather's *Analysis*—

	Dumraon Farm Crop. Castor-cake Plot.	Cattle-dung Plot.
Percentage of sugar to juice	13·76	16·09
Do. of glucose in juice	0·70	0·23
Specific gravity at 15·5° C.	1,067	1,074

Pansábi

Variety—*Pansábi.*
Where grown—Behea.
General appearance—A cane taller than the *mungo* and *bhurli* with which it is grown; green and yellow green coloured; erect; black patches frequent.

Type—D.
Bloom—Not much.
Nodes—Ring N_1—Indistinct; narrow; orange.
Band N_2—Drab coloured; root dots indistinct.
Band N_3—Gray.
Height—4 to 6 feet.
Girth—2″ to 2½″.
Internodes—2″ to 4″.
Aerial roots—Common at lower end.
Buds—Small and round.
Dry leaves—Open out from cane.
Dr. Leather's *Analysis*—

Percentage of juice to cane	53·50
Do of sugar to juice	14·56
Do. of glucose in juice	0·44
Specific gravity at 15·5° C.	1,071

Variety—Khári. Khári.
Where grown—Dumraon and Burdwan.
General appearance—A tall, thin, hard, yellow green cane; sometimes pinkish coloured where exposed; at Dumraon quite straight; at Burdwan much bent at upper end; frequently many black patches; scorings common.
Type—D.
Bloom—Much.
Nodes.—Ring N_1—Very distinct; orange coloured.
Band N_2—Narrow; drab; root dots indistinct.
Band N_3—Not very distinct.
Height—6 to 8 feet.
Girth—2¼″ to 2¾″.
Internodes—3½″ to 5″.
Aerial roots—Some.
Buds—Large; groove very little developed.
Dry leaves—Open out partly.
Dr. Leather's *Analysis*—

	Dumraon Castor-cake Plot.	Farm Crop. Cow-dung Plot.	Burdwan Castor-cake Plot.	Farm Crop. Cow-dung Plot.
Percentage of juice to cane		...	...	61·80
Do. of sugar to juice ...	10·90	15·43	16·59	18·96
Do. of glucose in juice	0·71	0·32	1·03	0·36
Specific gravity at 15·5° C. ...	1,059*	1,073	1,078	1,084

* Much laid.

Puri.

Variety—*Puri.*

Where grown—Burdwan.

General appearance—A clean yellow or yellow green cane; straight; no scorings.

Type—B.

Bloom—None.

Nodes—Ring N_1—Fairly distinct; narrow; lemon coloured.
Band N_2—Cream coloured; root dots distinct.
Band N_3—Very distinct; gray.

Height—4 to 6 feet.

Girth—$2\frac{1}{2}$".

Internodes—$2\frac{3}{4}$".

Aerial roots—Some.

Buds—Small.

Dr. Leather's *Analysis*—

Percentage of juice to cane	72·10
Do. of sugar to juice	18·02
Do. of *gur* to cane	11·30
Do. of glucose in juice	0·76
Specific gravity at 15·5° C.	1,083

Dikchan.

Variety—*Dikchan.*

Where grown—Cawnpore; Shahjáhánpur.

General appearance—Yellow green coloured some black patches inclined to grow crooked.

Type—D.

Bloom—A good deal.

Nodes—Ring N_1—Distinct and very broad; sometimes as broad as the Band N_2.
Band N_2—Yellow or green coloured; root dots very prominent.
Band N_3—Blue gray.

Height—8 to 10 feet.

Girth—2" to $2\frac{3}{4}$".

Internodes—$4\frac{1}{2}$" to 5".

Aerial roots—Very frequent and extend a long way up the cane; only at lower end at Shahjáhánpur.

Dry leaves—Remain folded.

Dr. Leather's *Analysis*—

Percentage of sugar to juice	10·99
Do. of glucose in juice ...	0·49
Specific gravity at 15·5° C.	1,060

Dhaul; dhaur.

Variety—*Dhaul; dhaur.*

Where grown—Cawnpore; Bareilly; Shahjáhánpur.

General appearance—Mainly drab coloured, but tinged with green at the top and bottom ends ; scored longitudinally.

Type—B.

Bloom—Good deal.

Nodes—Ring N_1—Distinct ; orange coloured or brick red ; frequently broader at one side than at the other.

Band N_2—Drab or green coloured ; root dots distinct and prominent.

Band N_3—Gray coloured.

Height—6 to 8 feet.

Girth—2″ to 2¼″.

Internodes—5″ to 6″.

Aerial roots—Occasionally at lower end.

Dry leaves—Remain folded tight.

Dr. Leather's *Analysis*—

Percentage of sugar to juice	13·32
Do. of glucose in juice	0·57
Specific Do. at 15·5° C.	1,066

Variety—*Rehá*. Matna.

Where grown—Cawnpore and Shahjáhánpur.

General appearance—Green and drab coloured ; fairly straight, but the tall ones bend at the top ; scored longitudinally : black patches infrequent.

Type—B, sometimes C.

Bloom—Good deal.

Nodes—Ring N_1—Orange coloured and moderately distinct.

Band N_2—Drab ; root dots very distinct.

Band N_3—Very indistinct.

Height—7 to 8 feet.

Girth—2″ to 2¼″ at Cawnpore ; 2″ to 3″ at Shahjáhánpur.

Internodes—4″ at Cawnpore ; 2″ to 3″ at Shahjáhánpur.

Aerial roots—None.

Dry leaves—Remain folded.

Dr. Leather's *Analysis*—

Percentage of sugar to juice	13·36
Do. of glucose in juice	0·77
Specific gravity at 15·5° C.	1,067

Variety—*Pansábi*. Pansábi.

Where grown—Gorakhpore.

General appearance—A pale green to yellow cane ; straight, inclined to sprout at upper end. This is probably not the same as the *Pansábi* grown at Behea.

Bloom—Some.
Height—6 feet.
Girth—$2\frac{3}{4}$".
Internodes—$4\frac{1}{2}$" to 5".
Aerial roots—None.
Dry leaves—Remain folded.

Chuni. *Variety*—*Chuni.*
Where grown—Bareilly, Shahjáhánpur.
General appearance—Mostly yellow, with pale green; very like *rákra*; but the internodes are longer, and the Band N_3 is much darker.
Type—B.
Bloom—Good deal.
Nodes—Band N_3—Distinct; blue gray. ...
Height—4 to 6 or 7 feet. ...
Girth—2" to $2\frac{1}{2}$". ...
Internodes—4" to 6". ...
Aerial roots—Common at lower end. ...

Sarauti. *Variety*—*Sarauti.*
Where grown—Bára Banki.
General appearance—A white cane; bluish coloured at nodes.
Bloom—A little.
Height—3 to 4 feet.
Girth—$1\frac{1}{2}$" to $2\frac{1}{2}$".
Internodes—$2\frac{1}{2}$" to 3".
Aerial roots—Infrequent.

Kaswár. *Variety*—*Kaswár.*
Where grown—Bára Banki.
General appearance—A bluish white coloured cane, straight.
Bloom—Some.
Height—3 to 5 feet.
Girth—$1\frac{3}{4}$" to $2\frac{1}{4}$".
Internodes—$2\frac{1}{2}$" to 3".
Aerial roots—None.
Dry leaves—Remain folded tight.

Kitáva. *Variety*—*Kitáva.*
Where grown—Shahjáhánpur and Bára Banki.

General appearance—A pale yellow to green cane.
Bloom—Fair amount, especially at nodes.
Nodes—Almost colourless and smooth.
Height—4 feet.
Girth—2″ to 2¾″.
Internodes—3″ to 4.″
Aerial roots—A little at lower end.
An experiment made by Mr. Ricketts, Special Manager of Court of Wards' Estates, Bára Banki, on 728 square feet gave the following results. It is equal to an outturn of 2,154 lbs. *gur* per acre. The land was unirrigated alluvium.

	Lbs.
Cane	500
Juice	316
Gur	36
Percentage of juice to cane	62·9
Do. of *gur* to cane	7·2

Variety—*Rehra.* Rehra.
Where grown—Gorakhpore.
General appearance—A pale yellow cane; inclined to sprout at the top end.
Bloom—Some.
Nodes—Smooth.
Height—5 feet.
Girth—2¾″.
Internodes—2″ to 3½″.
Aerial roots—None.
Dry leaves—Open out more or less.

Variety—*Rámwie.* Rámwie.
Where grown—Sitápur, Bára Banki.
General appearance—A yellow cane with pink patches; smooth and straight; does not sprout.
Bloom—Much.
Nodes—Smooth, with orange ring above them.
Height—4 to 6 feet.
Girth—1½″ to 2″.
Internodes—3″ to 6″.
Aerial roots—Common at lower end.
Dry leaves—Remain folded.

The following figures were obtained in experiments made by Messrs. Martin and Ricketts, Special Managers, Court of Wards' Estates, Sitápur and Bára Banki. Mr. Martin's test was taken on $\frac{1}{32}$ acre, and shows an outturn of 1,824 lbs. *gur* per acre; Mr. Ricketts' was on 1,029 square feet, and is equal to 2,270 lbs. *gur* per acre.

	Mr. Martin's Test. (Sitápur.)	Mr. Ricketts' Test. (Bára Banki.)
	lbs.	lbs.
Cane	798	500
Juice	420	289
Gur	57	56
Percentage of juice to cane ...	52·6	57·8
Do. of *gur* to cane ...	7·1	11·2

Parrárah.

Variety—*Parrárah.*

Where grown—Sitápur.

General appearance—A straw yellow to pale green coloured cane; fairly straight.

Bloom—Good deal of pale blue.

Nodes—Dark green above node.

Buds—Inclined to sprout.

Height—5 to 6 feet.

Girth—$2\frac{1}{2}$" to $2\frac{3}{4}$".

Internodes—3" to $4\frac{1}{2}$".

Aerial roots—None.

Dry leaves—Remain folded tight.

A test made by Mr. Martin, Special Manager of Court of Wards' Estates, gave the following outturn on $\frac{1}{32}$ acre, which is equal to 2,848 lbs. *gur* per acre.

	Lbs.
Cane	1,063
Juice	577
Gur	89
Percentage of juice to cane	54·2
Do. of *gur* to cane	8·3

Variety—*Kúrwie.*

Where grown—Bára Banki.

General appearance—A pale yellow cane; thinner at lower end than at upper end. This cane appears to be similar to *chuni.*

Bloom—A good deal.

Nodes—Smooth; Ring N_1 distinct and orange yellow coloured.

Height—3 to 5 feet.

Girth—$1\frac{3}{4}$" to 2".

Internodes—3" to 5".

Aerial roots—Some at lower end.

Dry leaves—Remain folded tight.

Thun.

Variety—*Thun.*
Where grown—Shahjáhánpur.
General appearance—A yellow green cane, much inclined to sprout along its whole length ; straight.
Bloom—None.
Height—4 to 5 feet.
Girth—$3\frac{3}{4}$″ to 4″.
Internodes—$2\frac{1}{2}$″ to $3\frac{1}{2}$″.

Munga.

Variety—*Munga.*
Where grown—Bára Banki.
General appearance—A yellow and bright green coloured cane ; straight.
Bloom—Hardly any.
Height—6 to 7 feet.
Girth—$1\frac{1}{2}$″ to 2″.
Internodes—4″ to 6″.

Munga

Variety—*Munga.*
Where grown—Shahjáhánpur.
General appearance—A bright green coloured cane ; inclined to grow crooked. It is doubtful whether this is the same variety as that called *munga* at Bára Banki.
Type—D.
Bloom—Hardly any.
Height—6 feet.
Girth—2″ to $2\frac{1}{4}$″.
Internodes—$2\frac{1}{4}$″ to 4″.
Aerial roots—Common for three-fourths of the whole length.

Rákra.

Variety—*Rákra.*
Where grown—Shahjáhánpur.
General appearance—Colour almost white.
Type—B.
Bloom—A little.
Nodes—Ring N_1 distinct ; yellow.
Height—7 feet.
Girth—2″ to $2\frac{1}{4}$″.
Internodes—$2\frac{1}{2}$″ to $3\frac{1}{2}$″.
Aerial roots—None.
Dry leaves—Remain folded tight.

GINGER—*Zingiber officinale*—Roscoe.
Natural order—*Scitamineæ*.

Habitat. Maráthi, *Ále*; Gujaráti, *Ádu*; Kanarese, *Alla*.

General character of the plant. Watt says, "Ginger is not known in a wild state, but it is, doubtless, a native of tropical Asia, in which it has been cultivated and exported from very remote times. It is now grown in all hot climates. In India it is grown in all the warmer parts, but chiefly in the plains."

This plant belongs to a family of aromatic herbs with creeping root stocks or rhizomes. Turmeric and cardamom belong to the same family. The ginger plant is a perennial. The stems are about 18″ to 24″ high in a good crop, and do not branch. The leaves are linear lanceolate. The plant rarely produces flowers in the Bombay Presidency.

Distribution in the Bombay Presidency. The crop occupies from 1,000 to 1,500 acres annually in the Presidency Proper. It is a very important crop in Baroda Territory. Ahmedabad grows 300 to 400 acres, Kaira 300, Surat 200, Sátára 120, Thána 200. In other districts of the Presidency the cultivation is very trifling.

Soil. Ginger likes a deep, rich, free working soil, which is naturally well drained. It grows to great perfection on the deep, alluvial, sandy loams (*goráḍu*) of Kaira and Baroda. The garden land of Surat in which the crop is important is somewhat heavier, but of the same general character and consistence. In the Thána District, where the rainfall is heavy, the crop is only grown in the strip of deep, sandy soil which fringes the coast in the Máhim and Bassein Tálukas.

Rotation. In Thána, ginger is rotated with betel vines, plantains and sugarcane. In Northern Gujarát it is rotated with a number of other garden crops, such as sugarcane, *surans*, turmeric, onions, garlic, chillies, brinjals, cabbages, *methi*, &c. Most of these crops are found in different patches in the same garden in a single year.

Mixtures. Ginger in Thána is grown alone. In Northern Gujarát, a thick sprinkling of *guvár* is sown with the crop. Yams are planted at the corners of the beds and along the *bándhs* which separate the beds, or, instead of yams, turmeric may be so grown.

Cultivation in the Kaira District.

Early in May, about forty loads of old farm yard manure should be given per acre. Tank mud is sometimes used instead of part of the above dressing. The tank mud requires some time to weather into a pulverized condition, and is therefore carted on to the land in April or earlier. The land is watered to admit of ploughing, and when properly dry, ploughing begins. The land is ploughed as

often as is necessary to loosen the soil to a considerable depth and secure a fine state of tilth. Four to six ploughings with the light *hal* are needed. If left untouched for a fortnight after ploughing, the surface becomes quite friable, and *kyáras* or beds should at once be formed. These are laid out with exactness. The compartments are usually 8 cubits by 4 cubits (about 12 feet by 6 feet), and a water channel runs between each double line of these. Thus the water channels are 8 cubits distant from each other. If the ground is uneven, the beds may be of smaller size; but wherever the ground is tolerably level, the size mentioned is common.

The sets and planting.

The ginger sets which consist of pieces of the rhizome bearing two or three buds are now planted with the greatest regularity in rows at a depth of 2 inches below the surface and a span (9 inches) apart in each direction. With a narrow *páedo*, the cultivator dexterously forms a number of equi-distant little pits in the *kyára*. The sets are pressed down into these pits, covered with soil, and the whole surface smoothed with the hand. In a *kyára* (8 cubits by 4 cubits) 144 sets are planted. Allowing for water channels, about 550 beds go to the acre. Consequently, an acre requires about 77,000 sets. 1,200 to 1,500 lbs. are sufficient to plant an acre, but the weight of sets varies somewhat with the size of the rhizomes from which they are cut. The seed rate is, therefore, sometimes about 2,000 lbs. per acre. A given weight of sets cut from well developed rhizomes will not go so far in planting as the same weight cut from rhizomes which are not so well developed. Well developed rhizomes, however, produce the best sets. There is a general belief among cultivators of Baroda and of the Kaira District of Gujarát that ginger for planting purposes should have been grown in a soil that had not been previously irrigated for some years. They bring ginger for sets from the Ahmedabad Collectorate, because they think and say that their own would rot in the ground. Planting takes place in May or early in June before the monsoon breaks, and immediately the sets are in the ground, water is applied. Along with ginger seeds of *guvár* are often sown a decided sprinkling over the whole ground. The variety commonly grown is *sotia*. It grows in rich garden land about 8 feet high, and yields pods which are esteemed as a vegetable. The *guvár* shades the young ginger. The side leaves are stripped off as the pods are plucked, and thrown down in the ginger as a green manure. The *guvár* should be uprooted and removed as soon as the green pods are all plucked. The leaves, if not used as green manure, are used as cattle food, and the stalks, when dry, as fuel.

Guvár subordinate to ginger.

In Gujarát, generally, castor cake is always given in repeated top dressings after the crop has made some progress. Rich, well-to-do

Top dressing with manure.

cultivators give as much as 3,000 lbs. per acre in addition to the farm yard manure applied before plantation. In the Máhim gardens an application of castor cake alone is used, and 3 tons (sometimes more) per acre are given in three top dressings—the first in July, the second in August, the third in September, the last being the heaviest. The castor cake should be crushed to a fine powder before application, and stirred into the soil with the *khurpa* (weeding hook).

Weeding

Weeding is thoroughly done by hand tool (*khurpa*) ; the crop may have to be gone over from three to six times according to the condition of the field. Two of the most troublesome weeds are *chido* and *luni*. The former (*Scirpus maritimus*) is a grass-like sedge, with fibrous roots and vertical root stocks which descend 8 to 12 inches below the surface, and there connect with an extensive system of rhizomes, which it is next to impossible to eradicate. The latter (*Portulaca quadrifida*) is a small dicotyledon, with a creeping aerial stem rooting at the joints and bearing fleshy leaves. It overruns the surface with great rapidity, and would quickly do great damage if not removed.

Irrigation.

Ginger, on the lighter descriptions of soil, must be watered every six days until the rains. If thereafter there is a break in the rainfall of more than ten days' duration, irrigation must be resumed. When the rains cease, irrigation is required every sixth day until the crop is ripe. The crop is ready for harvest by November or December, but no certain rule can be given. A liberal application of manure—particularly a top dressing of castor cake—would hasten maturity by a month or more.

Harvestin

Ginger is dug by hand with a small native hand pick, and is sold to a dealer who either sells it as ginger or converts it into *sunth*, in which form it is used for condiments and medicines.

Outturn and valuo.

Under favourable conditions, an acre may yield 12,000 lbs. of dry cleaned rhizomes. The sun dried partially cleaned rhizomes are sold by the cultivators to dealers at 40 to 50 lbs. per rupee in ordinary seasons. Selected pieces of rhizomes after storage for several months are worth as sets for re-planting about 25 lbs. per rupee. A crop test which was taken in the Surat District in good garden land in 1895-96 gave for a mixed crop of ginger and turmeric the following outturn results :—

	Per Acre. Lbs.
Ginger	8,337
Turmeric	3,564

The storage of ginger in its fresh state.

The central room of any ordinary well built house is usually cool and, therefore, more suitable than a warmer apartment for the storage of ginger. A cool moist atmosphere and ventilation are required. The ginger should be sorted before it is stored, and any decayed por-

tions removed. The apartment is prepared by digging up the earthen floor 10" to 12" deep and by soaking the upturned earth with water. The water is absorbed in eight or ten days, and the floor then becomes dry enough. The sun dried sorted ginger is then built up in a heap to a height of 4 to 5 feet. If the room is large, and the ginger not sufficient to fill it, the heap is built to the required height on a portion of the floor. The heap when finished is covered with dry dead turmeric or ginger leaves which are sprinkled with water. The heaps are examined periodically once a fortnight or oftener. If the ginger in the centre of the heap is found hot or warm, the whole is removed from the room, and any decaying or rotten pieces separated. In three or four days the ginger is again heaped up. If the heap remains cool during storage, the owner knows that the ginger is taking no harm. In April and May the doors of the room should be kept open, as the outside temperature is then very high, and the storage room should be ventilated as much as possible. During the very hot weather the stored ginger should be often carefully examined, as it is apt to go wrong at this time, and the prompt removal of decaying portions is absolutely necessary. Ginger can be stored as described for seven or eight months. Ginger during storage loses weight by dryage, and also a certain proportion gets rotten. This loss will vary from 15 to 20 per cent. in well stored ginger and from 20 to 40 per cent. in ginger less carefully stored. The dealer, however, who stores green ginger waters it before he offers it for sale. The water is absorbed, and the ginger is increased in weight.

The preparation of *sunth* (dry ginger) from green ginger in the Surat District.

The best *sunth* is prepared from well developed, properly matured rhizomes. The best shoots of each rhizome are equally well suited for *sunth* or as sets for planting. The residue left when the best shoots are removed is called *sakat*. This will yield 14 to 16 per cent. of inferior *sunth*, while the well developed selected shoots will yield 18 to 23 per cent. *sunth*.

The ginger when it is dug is sun dried, and then adhering earth is removed as far as possible. The first operation in *sunth* making is to soak the partially cleaned rhizomes in water. This with rubbing cleans the rhizomes, and also softens them. The soaking facilitates the removal of the outer skin. It is scraped off with a shell or broken piece of earthenware. The scraped ginger is now washed and exposed for three or four days to the sun on an ordinary threshing floor. The ginger is thus bleached and dried. It is now rubbed by hand. The object is not clear. The operation is done carefully, so that the shoots are not broken. The ginger is again bleached in the sun for three or four days, and again hand rubbed. It is now steeped in water for two hours,

and exposed on a clean floor to the sun until it gets dry. When dry, it is rubbed on a coarse cloth or coarse sacking. This removes any outer skin not previously removed by scraping. The *sunth* is now ready for market. The cost of *sunth* making is about Rs. 3 per *khandi* of 20 maunds of green ginger. A Surat maund is 40 *sers* of 38 *tolas* (39 *tolas* per lb.).

Cost of cultivation, Surat District.

	Per Acre. Rs.	a.	p.
Manure 30 loads and spreading	16	0	0
Preparatory tillage—6 ploughings with light *hal*, 2 harrowings, once levelled with plank roller	6	8	0
Making beds and water channels and levelling beds ...	3	8	0
Digging pits and planting ginger	4	0	0
Cost of ginger sets 1,500 lbs. per acre. (This quantity after storage is equal to about 2,000 lbs. of selected sets sufficiently dry for storage.)	70	0	0
Top dressing with castor cake 2,000 lbs. per acre ...	25	0	0
Hand weeding four times and earthing up ginger plants in September	7	0	0
Irrigation—watering three times before rains, four times during rains and eight times after rains	40	0	0
Digging and cleaning ginger (good crop)	11	0	0
Rs.	183	0	0

TURMERIC—*Curcuma longa*—Roxb.

Natural order—*Scitamineæ*.

Maráthi, *Halad* ; Gujaráti, *Haldar* ; Kanarese, *Arshana*.

General character of the plant.

This is a perennial herbaceous plant which is cultivated for the sake of its rhizomes. The leaves have long leaf stalks, with long moderately narrow blades, widest near base and thence tapering to a point. The flowers are "yellow, arranged in spikes, each in the axil of a greenish or purplish red bract. The summit of the spike is composed of the empty bracts which are white, tinged with pink." (Duthie and Fuller.)

Habitat.

Simmonds says that Curcuma longa grows wild in Mysore. Some varieties of Curcuma are undoubtedly found wild in India. Some writers appear to have mistaken these for a wild form of Curcuma longa. Dr. Watt thinks it is a Chinese or Cochin Chinese species.

Varieties.

There are two distinct varieties—

(*a*) with hard, rich coloured rhizomes, from which a yellow dye is obtained ;

(*b*) with softer, larger, lighter coloured rhizomes which are edible.

Turmeric is extensively cultivated all over India. In 1898-99 the Bombay area was 5,300 acres. Sátára is much the most important centre of cultivation, and claims four-fifths of the whole. Sholápur and Belgaum grow fair areas. Throughout Gujarát the crop is important as a subordinate crop with ginger, and the area returns for Gujarát are therefore estimates. Distribution.

Turmeric does best in medium black soil naturally well drained. Such land in the Deccan with canal or well irrigation is capable of growing all kinds of garden crops. Lighter descriptions of garden soils are better suited for ginger than for turmeric. Soils.

Yams are generally grown subordinate to turmeric, the turmeric being planted in the beds, the yams from 2½ to 3 feet apart along the borders of the beds, with chillies at the corners. Sometimes ginger is planted in the beds, and the turmeric occupies the borders only. Mixtures

On mixed black soil in the Deccan, turmeric is rotated with sugarcane, chillies, groundnuts, onions, irrigated wheat, gram, &c., and the land is occasionally rested from irrigation; then dry crops of *jowár*, *bájri*, &c., are grown. In Gujarát on garden land the crop is rotated with sugarcane, ginger, onions, garlic, *surans* and the other ordinary garden crops. Rotations.

Ginger and turmeric are usually cultivated together on deep, free working, loamy soils. The two crops are closely related from a botanist's or agriculturist's points of view, and are well suited for mixed cultivation. The long straight turmeric leaves stand above the level of the ginger, and thus get abundance of light and air. Moreover, they give to the ginger beneficial shade. Turmeric as a mixed crop with ginger gets the same treatment as the latter. The cultivation (*i.e.*, the preparatory tillage, planting, weeding, top dressing, and watering) is identical with that already described for ginger. The sets of turmeric are selected pieces of rhizomes, with two or three eye buds. 600 to 800 lbs. of good sets per acre are required to plant the borders of ginger beds. The turmeric sets are planted 12 to 15 inches apart. Turmeric is ripe when the leaves die down. It is dug up about December-January with a small hand pick, generally after the ginger is removed. Ginger and subordinate turmeric.

Cultivation of Turmeric and Yams in Gujarát.

The land is prepared and laid out into beds 12′ × 6′ as for ginger. 1,800 lbs. to 2,000 lbs. per acre of turmeric and 600 lbs. to 700 lbs. per acre of yams are required to plant an acre. A yam of full average size gives six to eight sets for planting. The turmeric sets

are planted in equi-distant pits dug from 12″ to 15″ apart in the beds. The pits should be about 3″ deep. Each set is placed in a pit and carefully covered with loose soil pressed down over it. The yam sets are each planted in pits dug 4″ deep along the borders and 2½ to 3 feet apart. Very often seeds of chillies are sown at the corners of the beds, and three or four seedlings left in each clump to grow. The crop needs careful hand weeding from time to time, and irrigation, when needed, every eighth day. If

Harvesting. the crop is planted in May, it is dug up in December-January or February. Neither the turmeric nor the yams are damaged by being left in the field after maturity. They are dug up usually as the owner finds a good market—the turmeric by means of a small pick, the yams by means of a pick with an iron piece some 15″ long. The yams are deeply buried in the soil, and it is an expensive process digging them out without breaking or damaging the tubers.

Outturn results. Two crop tests taken in 1895-96 in good garden land in the Surat District gave the following outturn results ; each crop was considered full average :—

	First Test. Per Acre. Lbs.	Second Test. Per Acre. Lbs.
Turmeric	13,570	14,842
Yams	6,022	9,014

The above weights represented the weights of the mixed crop as dug by actual test. It was found that the ratio of cleaned green turmeric with old sets removed to uncleaned turmeric as dug was as 11 to 16.

Value. Cleaned green turmeric as sold by the cultivator to the dealer is worth in ordinary seasons 60 to 70 lbs. per rupee. The loss by dryage subsequently is very considerable. Turmeric sets are worth about Rs. 25 per *khandi* of approximately 780 lbs.

Diseases. The turmeric crop in the Bombay Presidency is practically exempt from any kind of disease. During excessive rain on medium black soil the sets rot.

The dye. The variety commonly grown for dye is called *lokhandi halad*, and has very hard rhizomes. Turmeric yields a fleeting dye of a dull yellow colour. The rhizomes after being boiled are mashed to a pulp, and a decoction is made from the paste. In this cloth may be dyed ; but, as already noticed, the dye is not fast. The action of an alkali change the colour to red.

Cost of cultivating Turmeric and Yams, Surat District.

	Per Acre. Rs.	a.	p.
Manure—40 cart loads ordinary manure and spreading.	21	0	0
Preparatory tillage—6 ploughings with light *hal*—2 harrowings and levelling with plank-roller	6	8	0
Making beds and water channels and levelling beds ...	3	8	0
Digging pits and planting turmeric and yams ...	4	0	0
Cost of turmeric sets 1,800 lbs.	55	0	0
Cost of yam sets 600 lbs.	12	0	0
Hand weeding four times...	4	8	0
Irrigation—watering three times before rains, four times during rains and eight times after rains ...	40	0	0
Digging and cleaning turmeric	9	0	0
Digging and cleaning yams	4	0	0
Rs. ...	159	8	0

THE ELEPHANT'S FOOT—*Amorphophallus campanulatus*—Blume.

Natural order—*Aroideæ*.

Gujaráti, *Suran*; Maráthi, *Suran*; and Kánarese, *Suran*.

General character of the plant.

This is a perennial, stemless herb which is cultivated for the sake of its corm. The round, tapering, variegated leaf stalks rise singly or in pairs from each corm and carry the leaf horizontally at the top. "The leaf blade is large, twice bifid, the divisions outwardly pinnatifid, ultimate segments oblong acute." (Duthie and Fuller.) The corm when fully grown is a foot more or less in diameter. Its shape somewhat resembles an elephant's foot, hence the name. There is one central eye-bud, and in a large corm several lateral tuberous excrescences, each of which, if cut off and planted, will grow in the first season into a very small *suran*.

Habitat.

Dr. Watt says the *suran* is a native of India and Ceylon, and is cultivated throughout the Peninsula in rich moist soils.

Distribution in the Presidency.

The area under this crop is not separately returned. The crop is important, chiefly in Gujarát and Baroda Territory.

Soils.

The best crops in the Bombay Presidency are grown on the deep, alluvial, sandy (*gorádu*) soils of the Charotar villages of Kaira and Baroda, and in somewhat similar soil in the garden lands of the Surat District. In the Deccan the *suran* thrives excellently on mixed black soil, such as suits other irrigated crops.

Mixtures.

The crop is usually grown alone, excepting that *san* (*Crotalaria juncea*) is thickly broadcasted between the *surans* and allowed to grow to a height of 2½ to 3 feet. The *san* is then uprooted, broken up by hand, and laid down on the surface as a green manure.

Cultivation. The *suran* is a gross feeding plant which requires plenty of manure and heavy irrigation. The plant is propagated, in the first instance, from the tuberous excrescences which are cut from fully developed corms. A big corm will yield five to eight tuberose buds for planting. These buds weigh from 1 to 4 ounces each, the average size weighing about 2 oz. Buds of average size should be planted at the rate of sixty to eighty in a bed 12 feet × 6 feet. For the first year's crop less manure is required than for the crop grown from bigger corms in subsequent years. But the preparatory tillage must be thorough, and at least thirty cart loads of farm yard manure per acre applied. The preparatory tillage should be complete early in May. Beds 12′ × 6′ are now formed, and the buds planted in shallow equi-distant pits. On the surface of the bed over each bud a layer of mango, &c., leaves should be put as a protection against the scorching heat of the sun. Water is given at once, and the field will require three or four waterings before the rains. Irrigation is required during breaks in the rains and regularly once a week after they cease. The crop is carefully hand weeded as required during growth. The leaves die down in November-December, and the first year's produce is then dug. It consists of small, properly shaped corms which weigh about 4 oz. to 6 oz. each. These when dug out and dried in the sun are heaped up under shade, and kept for re-planting *on a different area* in the following May.

Cultivation, cond year. Forty small corms are planted in a bed 12′ × 6′. The cultivation is precisely the same as in the first year. In January the second year's crop is dug out. The corms weigh 1 to 1½ lbs. They are heaped up in the shade, and re-planted again in a different area in May—fifteen in a bed. The tillage being the same as already described, forty loads per acre of manure should be given, and at the time of planting *san* should be broadcasted thickly in the beds as a green manure. The *san* grows quickly, and gives beneficial shade to the *suran* leaves. The produce dug out in January consists of *surans* which weigh from 3 to 5 lbs. each. The larger sizes are sold, the smaller re-planted in May again on a different area. A heavy dressing of manure of at least forty cart loads per acre is given, and again *san* is grown as a green manure. The *san* smothers weeds, and the same extent of hand weeding is not required as in the first two years. Either six or eight *surans* are planted in a bed in the fourth year. This year's crop has an extremely handsome appearance. When in full vigour of growth, the leaves stand quite 4 feet high, and completely shade the ground.

Cultivation, third year.

Cultivation, fourth year.

It is customary to sow in this crop seeds of *dudhi* (*Lagenaria vulgaris*), bottle-gourd, two at the end of each bed. The plants grow vigorously, and should be layered down here and there, so that, when the *surans* die down, the *dudhi* stems completely shade the ground. A good crop yields 8,000 to 10,000 lbs. of bottle-gourds per acre. The *dudhi*, if planted in October, becomes exhausted by February. Irrigation should then cease, and the *surans* dug out when the soil sufficiently dries. The *surans* of the fourth year weigh from 10 to 20 lbs. each, some particularly well developed corms being heavier. In an acre (allowing for water channels) there are, say, 560 beds ; 3,360 *surans* will be obtained per acre. At a very moderate estimate these will weigh 15 tons.

A subordinate crop grown in the fourth year.

Outturn and value of fourth year's crop.

The gross value of produce at an average market rate of Rs. 25 per *khandi* of 780 lbs. comes to Rs. 1,077 per acre.

The cultivation of these crops can only be undertaken by well-to-do cultivators, a large amount of capital being sunk particularly in the fourth year on account of the value of the sets planted. *Surans* have been known to weigh 40 lbs. or more, but that weight is quite unusual. The corm keeps good for a considerable period, if stored quite dry in heaps in a well ventilated room.

An expensive crop to grow.

Cost of cultivating Surans in the Fourth Year, Surat District.

	Per Acre. Rs.	a.	p.
40 cart loads ordinary manure and spreading	21	0	0
Preparatory tillage—6 ploughings with light *hal*, 2 harrowings and levelling	6	8	0
Making beds and water channels	3	8	0
Making pits and planting *surans*	5	0	0
Sowing *san* and cost of seed 60 lbs. per acre	2	0	0
Cost of *surans* 12,000 lbs. per acre at Rs. 25 per *khandi* (780 lbs.)	385	0	0
Uprooting and breaking up *san* as green manure crop and twice hand weeding	6	0	0
Irrigation—three times before rains, four times during rains and ten times after rains	45	0	0
Digging and cleaning *surans*	10	0	0
Rs.	484	0	0

THE KACHU—*Colocasia antiquorum*—Schott. Syn., *Arum colocasia*.

Natural order—*Aroideæ*.

Gujaráti, *Alu* ; *Pánára*, or *Pándada*, for leaf ; *Alvi*, for corms; Maráthi, *Alu* ; Kanarese, *Shyámi*.

General character of the plant.

The long stalked, purplish, green, distinctly veined, large leaves spring from a corm. Leaves are "peltate, cordate, ovate; flowering stems shorter than the leaf stalks, spathe exceeding the spadix, cylindric erect." (Duthie and Fuller.) Established plants send out off-sets which root down and produce perfect plants. The leaves, stalks and corms have somewhat acrid properties before they are cooked. Several varieties are cultivated.

Cultivation, soils, &c.

The wild form of this arum is a weed in marshy places, and the cultivated plant grows best in damp situations. Patches are grown in the backyards of houses. *Alu* grows well under heavy sewage irrigation. In the garden lands of Gujarát it is common to find a patch of *Alu* near a well with single plants at the corners of beds of other irrigated crops and here and there through a garden. The crop is rarely grown over a large area. When grown alone, the land is carefully prepared as for other garden crops, and laid out into beds 12′ × 6′ for irrigation. Forty plants occupy each bed. The crop should be freely manured and watered, also weeded as required. Off-sets should be removed before they root, unless it is desired that the whole surface should be covered with plants. This is, perhaps, advisable when the crop is grown under sewage irrigation for the value of its leaves and leaf stalks. If grown for its corm, the plants should be 12″ apart. It takes ten months for the corm to reach maturity.

Harvest.

When the crop is planted four or five months, the leaves and stalks may be gathered every three or four days. They should be cut off close to the ground whilst young and tender. A few older leaves should always be left to preserve healthy, vigorous growth.

Economic uses.

The corms contain much starch, and afford an important article of native diet to the rich as well as poor. Before being cooked, they are scraped, or partially peeled, and then cut up into small pieces. Boiling extracts the acrid principle which the corms contain. The first water used is thrown away. When sufficiently boiled, the soft pieces are fried in oil, and then subjected to a gentle heat in a close vessel. The usual native flavouring material and condiments are added, tamarind being specially necessary to counteract the acridity left. The stalks are sometimes cooked separately from the leaves. The thin fibrous cuticle is removed by hand and the stalk cut into short pieces. These when cooked are flavoured with condiments and *gul*. To this preparation is added boiling oil (*phodni*), in which mustard, assafœtida, cumin and turmeric are previously mixed. The prepared dish is a sweet curry. The leaves, as well as the stalks, are made into a preparation as under:—The stalks and leaves chopped fine are boiled with a pulse-

When cooked, the usual flavouring material is added. Sufficient *dâl* flour is added to give consistence, and a gentle heat applied. When sufficiently cooked, boiling oil (*phodni*) with the usual admixture of mustard, &c., is added. These are only one or two ways of the many in which the vegetable is utilized in native households.

SWEET POTATO—*Ipomœa batatas.*

Natural order—*Convolvulaceœ.*

Márâthi, *Ratâle*; Gujaráti, *Sakaria*; Kánarese, *Genasu.*

Habitat.

Sweet potatoes are believed to be indigenous to tropical South America, and were introduced into India in comparatively recent times.

General character of the two Bombay varieties.

Two varieties are in general cultivation throughout the Presidency. The variety most commonly cultivated has cordate, rather sharp-pointed, leaves, with long, vigorous growing vines or trailing stems. The leaves in a thriving crop have a peculiar bronze, shining appearance, and some leaves are irregularly lobed or indented. The flowers are pale purple. The tubers vary in size according to the vigour of the crop. They are always fairly long and spindle shaped. A luxuriant, well manured crop produces large, long red or purple red tubers, often 2″ in diameter at the middle and 8″ or 9″ in length, whilst those from an ordinary crop are rarely more than 1″ in diameter and 5″ or 6″ long. The red or purple variety is believed to be sweeter and less stringy or fibrous than the white variety.

The second variety with white tubers does not usually produce such a vigourous growth of vine and leaf as the red. It is grown in Ahmedabad, in parts of the Deccan, and is in general cultivation in parts of the Southern Marátha Country. The leaves are deeply indented like *math* (*Phaseolus aconitifolius*). The flowers are white, and the tubers larger and coarser than the red, and more uniform in shape.

Area in the Presidency.

Sweet potatoes are not very extensively grown in the Presidency. The area is about 12,000 acres annually.

Soils suitable and general condition of cultivation.

The crop occupies an important position, however, amongst garden crops, being suitable for considerable variety of soils. It will grow on the lightest description of sandy soil. It thrives on such soils if a liberal application of manure be given. It also does well on loams or even on soils still stiffer in character. It does best in such fields as are thoroughly well prepared by deep tillage, the soil being loosened and made friable to a considerable depth. The crop does not thrive except on naturally dry land, a water logged condition of soil causing

serious damages. It may be grown, however, on land in weedy condition with fair success, and then exercises an ameliorating influence, because the mass of trailing stems and leaves choke out surface weeds, and tend to suppress such as are more or less established. Moreover, in harvesting the crop, the soil has to be thoroughly dug to a depth of a foot or fifteen inches, and deep rooted weeds are thus destroyed. Sweet potatoes are very commonly grown in dry, river bed land, when the stream is small in the fair season.

Season of growth.

The crop is generally grown during the cold season and under irrigation, but in light dry land a rain crop is sometimes grown. It may be grown after such rain crops as quickly ripen, but usually is the sole crop of the year.

Cultivation of the rabi crop.

The land should be well worked during the monsoon by repeated ploughings and harrowings. In September a liberal dressing of well decayed farm yard manure should be ploughed in. Thirty cart loads per acre of manure is sufficient. Planting is usually done in October-November. The field before plantation should be laid out for irrigation by forming beds of convenient size. These are ordinarily 12 feet by 6 feet in Gujarát or 10 feet by 10 feet in the Deccan. The crop is propagated by cuttings, sometimes planted in flat beds, sometimes on ridges. The latter is the preferable plan. The cuttings are got from a nursery. In this nursery, cuttings from the vines or stems of the previous year's crop should be planted. Each cutting should consist of a fairly mature portion of a stem, with three nodes or leaf buds. Two of the nodes are placed under ground 2″ or 3″ deep, the other node with a portion of the cutting being free. These cuttings form roots from the under ground nodes, and during the monsoon produce vigourous growth of long, trailing stems from the bud or buds above ground, and from these stems the cuttings for the future crop are obtained.

The nursery.

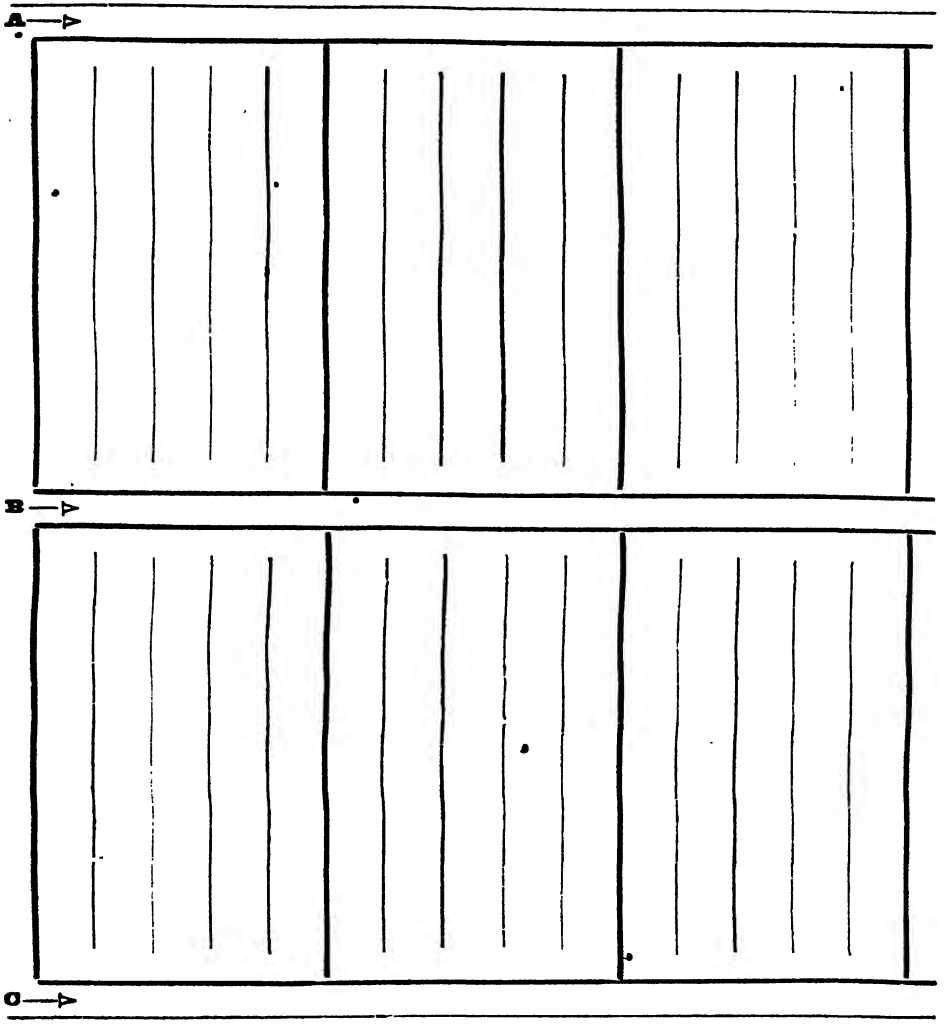
Cuttings.

The best cuttings are got from the middle portions of the stems. The root ends are rejected, also the tender succulent growing parts, the latter not being sufficiently matured for the purpose. All rootlets should be removed from the nodes before plantation.

Two methods of planting.

The cuttings if planted in flat beds are put in shallow pits dug in straight rows. The rows are 18″ apart and the space between two cuttings about 11″ to 12″. If the ridge method of planting is adopted, a small native plough is used to form straight ridges 18″ apart drawn across the field. Cross furrows are drawn 13 feet apart. These form

water channels for irrigation, and are represented by **A**, **B** and **C**



in the sketch. Beds or water compartments are made by hand spade by earthing up every fifth ridge and also the edges of the cross water channels, the soil required being got from the ends of the ridges inside each bed. Each water compartment thus contains four short ridges and five furrows. Cuttings are planted 1 foot apart on each side of each ridge half way between the crest of the ridge and the bottom of the furrow, also the same distance apart, and in the same position round the inside of the *bándhs* which form the watering compartments. About 100 to 120 cuttings are sufficient for a bed 12 feet × 6 feet.

Some will probably fail. These should be early replaced. If the ridge system of cultivation is adopted, the cuttings are kept sufficiently moist for satisfactory germination, but are not actually submerged in water. If planted in flat beds, they are submerged, and this is objectionable. The cuttings usually produce roots freely, and the young shoots above ground grow very rapidly. Weeding should be attended to until the crop shades the ground. Afterwards no attention in this respect is required. The crop should be watered every eight or twelve days according to the character of the soil.

Weeding.

Irrigation.

The stems come in contact with the wet soil after each watering and become attached to the soil by rooting at the nodes. This must be prevented, otherwise small thin tubers of no marketable value form at each point of attachment, and the tubers which form at the main root do not grow so large as when the stems are kept quite free. The stems during growth must be repeatedly lifted clear from the ground, and turned over to prevent the formation of these roots; and if the crop is good and the foliage luxuriant, these operations must be done oftener than in the case of a poor crop, but must be done with care, so that the stems and leaves are damaged as little as possible.

Turning the stems necessary to prevent rooting at various nodes.

Pruning.

In a luxuriant crop the growing points of the long trailing stems may be pruned off without damaging the crop in any way. These prunings provide in native households a delicate vegetable.

Signs of ripening.

It is not easy to determine when the crop is fully ripe. The stems or vines do not die down completely. Many of the leaves, however, turn yellow and drop off. The stems near the growing point get hard and fibrous. Such are the observable signs of maturity. The vines should be reaped close to the ground, cuttings selected for the nursery, and such of the vines or portions thereof as are green and succulent used as cattle fodder. As the crop approaches maturity, irrigation water should be withheld.

Harvesting.

If the soil is fairly dry and not sticky or adhesive, the crop can be dug out in clean condition and easier than from moist sticky soil. A pick with iron piece about 15 inches long is used for digging the crop, and in the hands of an expert labourer is very effective for the purpose. A man who is used to garden cultivation knows intuitively where he should insert the pick to expose the tuber most easily. Harvesting is an expensive operation. A poor crop will not pay expenses, whilst a good crop yielding 6 tons per acre gives a valuable outturn worth at average market rates Rs. 300 per acre. The outturn, however, rarely reaches the above standard. A crop planted in October-November ought to be ripe in April.

A crop test taken in the Surat District in 1895-96 yielded an outturn of 8,509 lbs. per acre, worth Rs. 203. This was the red variety. The white variety on the Surat Farm in 1899 yielded 8,560 lbs. tubers per acre. The red variety on the Poona Farm in 1901 gave 12,358 lbs. per acre. Outturn.

The vines or haulms should be reaped before the tubers are dug. The vines, if fairly green, are greedily eaten by cattle.

Sweet potatoes provide a favourite food in both native and European households in India. The tubers are generally cut lengthwise in two parts, and either boiled, roasted or fried. Dried tubers are sometimes ground into flour which is baked into cakes and eaten by Hindus on fast days. Economic uses.

Cost of Cultivation, Surat District.

	Per Acre. Rs.	a.	p.
Manure—30 cart loads ordinary manure and spreading	16	0	0
Preparatory Tillage—6 ploughings with *hal*, 2 harrowings and levelling with plank roller	6	8	0
Ridging, making beds and water channels	4	8	0
Cuttings and cost of seed bed	7	0	0
Planting cuttings	7	8	0
Hand weeding	1	8	0
Turning over vines to prevent rooting—twice done ...	1	0	0
Irrigation—20 waterings in fair season	60	0	0
*Removing vines, hand digging crop and cleaning tubers in medium black soil	30	0	0
Rs. ...	134	0	0

THE YAM—*Dioscorea.*

Natural order—*Dioscoreæ.*

Gujaráti, *Ratálu*; Maráthi, *Konphal* or *Gorádu*; Kanarese, *Heggenasu.*

The tuberous root stocks of various species of *Dioscoreæ* are known as yams. These are climbing herbs or small shrubs with twining stems. The stems may be round, four angled or six or more angled. The leaves are cordate, acuminate, net veined, stalked, and, when young, sometimes very brightly coloured; the flowers are unisexual, dioeceous and small. The tubers may be produced on the stems, as well as under ground. Some species yield tubers which are bitter and uneatable until rendered wholesome by being steeped in water or in water and ashes before being cooked. Others never lose their bitterness. The tubers of different varieties vary much in size, shape and colour. The colour may be white, yellow, red or purple. The darker skinned tubers have their flesh tinged with a lighter shade of the same colour. A white skinned variety may be yellow inside. The shape may be oblong, oval, round or kidney shaped. The size varies. General character of the plant.

* Operation cheaper in good, alluvial, garden land.

Several varieties are found wild in India. Some of the cultivated varieties have been introduced. Dr. Watt names 24 species, ten of which are extensively cultivated in India.

Bombay varieties.

Four varieties at least are grown in the Deccan and Gujarát.

(1) *Dioscorea alata*, Roxb., *Kham alu*.—Has a white fleshed, oblong tuber, which, under favourable conditions, grows to a large size. The stems are four angled. The trailing vines should be trained on poles or in any other convenient way. The tuber is of fair quality. Two or more are found at each root.

(2) *Dioscorea globosa*, Roxb. *Chupri álu* (*Kamodio*, Gujaráti).—This variety has white fleshed, rounded tubers which grow to a size of 8 to 10 lbs. in good, well manured soil. The plant has a six-angled stem. The *Kamodio* variety of Gujarát is considered of good quality. It has a fragrant smell like *Kamod* rice when boiled, hence the name.

(3) *Dioscorea purpurea*, Roxb., *Lál alu*, *Talabda ratálu*, a local variety of Gujarát.—The tubers are long, large in the middle, and taper to each end. Good specimens weigh 7 or 8 lbs. One large tuber or two or more smaller ones form at each root. The skin is dull purple. The flesh is tinged with red, but nearly white at the centre.

(4) *Dioscorea sativa*, Linn.—This is the commonest of the yams. Its quality is not so good in native estimation as the three others named above. The *Bhusra* variety of Gujarát probably belongs to *D. sativa*. It is long and thick, but does not bulge in the middle. The flesh is white. The skin is dark dirty brown. This is considered a coarse, inferior variety, but it grows to a size of 8 to 10 lbs.

Two other varieties are common in the Southern Konkan :—

(1) *Dioscorea aculeata*, Linn.—The prickly stemmed yam or Goa potato, called *Kangar* by the natives. The tubers of this variety are white, of fine quality, oval in shape and not large. The stems have prickles, and need not necessarily be supported by stakes. The crop is ready in six months if planted in June, and produces a cluster of kidney shaped tubers at each root. This variety is a native of various parts of India.

(2) *Dioscorea bulbifera*, Linn.—Wild on the Western Ghâts and elsewhere in India. It is called *Karanda* in the Konkan. This variety produces bulbs on the stems. These, as well as the underground tubers, are yellow fleshed. The wild variety is acrid, and requires steeping before boiling to remove the bitterness.

Distribution Bombay.

The area under yams is not separately returned. The crop is sparingly grown in most districts. The cultivation in the garden lands of Gujarát is most important.

Soils, rotations, mixtures, season.

The yam likes a deep, free working, sandy, loam soil, well stocked with manure. It grows fairly well in soils of a still heavier character. It is seldom grown alone, and is most generally a subordinate crop to ginger and turmeric. It is grown with these crops in the rotations of garden lands already described. The yam is essentially a rain crop, but generally needs irrigation to bring it to maturity.

Methods of propagation.

The crop is propagated in various ways. The only method followed in this Presidency is to cut up a large yam into sets, or use small tubers as such. Each set is separately planted. The Chinese have an ingenious plan of producing a large crop of small tubers. The long trailing vines from one set are layered to the soil at points where it is desired they should take root. The stem roots at a node, and, where it roots, a cluster of small tubers is produced underground. These are much the size and shape of common potatoes. This method of growing the crop obviates the necessity of training the vines. The plant may be propagated from the aërial tubers or bulbs. These, if planted as sets, produce a mature crop in two years. This method is not practised in Bombay.

Cultivation in Gujarát.

The crop participates in the tillage given for ginger or turmeric, as already described. The sets consist of pieces of tuber. A fairly large, oblong tuber can be cut into about eight sets. A small tuber may be planted whole. The beds are 12 feet × 6 feet, and round the borders of each bed ten sets are usually planted, one at each corner, two at equal intervals at each side, one intermediate at each end. The sets are put in pits 4″ deep dug with a pick, and, when planted, are carefully covered. They are distant from each other 3 feet. A set rarely fails to grow. The stems are generally allowed to trail and twine through the ginger and turmeric in the beds. They are not usually supported by stakes. Large, very well developed tubers are got when the stems are trained on a support. If the stems grow vigourously, the tubers are certain to be well developed, and a support certainly helps to produce luxuriant growth of the stems and foliage. The crop is ripe when the foliage dies down. The tubers are generally dug out in December-January, and in doing so a pick is used to move the earth to a depth of 15″ to 18″.

Cultivation in varkas land.

In the *varkas* lands of the Konkan the crop is sometimes grown alone, the sets are planted 3 feet apart, and the same distance between the rows. Poles are used to support the vines. The cultivation is not very careful. The natural rainfall is sufficient. The crop ripens in October. In the Konkan the outturn is 6,000 to 8,000 lbs. per acre, but a crop subordinate to ginger or turmeric would yield more. Yams subordinate to turmeric yielded on the Poona Farm in 1901 9,360 lbs. per acre, the gross produce of turmeric and yams being over 20,000 lbs. per acre.

Value. Yams in Gujarát as sold by the cultivator to the dealer are worth 50 to 60 lbs. per rupee in average seasons.

In Dr. Watt's "Dictionary of Economic Products" an interesting account by Mr. R. Mitchell, of Calcutta, is given regarding the cultivation of recently introduced West Indian and other varieties. I summarize briefly his results.

Mr. Mitchell's method of cultivating West Indian varieties. The experimenter's object was to introduce varieties of finer quality than the stringy, hard and earthy flavoured sorts commonly grown. He succeeded in acclimatizing some at least of the improved forms, and, though these produced large sized tubers (one weighed 82 lbs.), the fine, mealy quality and delicate flavour were maintained. Mr. Mitchell gave special care to the preparatory tillage, and believes in deeply trenching the soil and placing in the bottom of each trench a quantity of decayed or decaying vegetable material. The effect is to produce a seed bed, pulverized and open to a depth of 18 inches, which, moreover, is full of organic matter. It can be readily understood that yams or, indeed, any tuber bearing crop will succeed in land prepared in this manner. The friable open soil permits the tuber to freely expand. The sets about the size of a man's fist, cut so as to preserve as much of the out surface as possible, are planted 3 feet apart in each direction. They should be first made to sprout under a layer of grass and earth, occasionally watered. They sprout in three to six weeks, and should be planted out at once. The vines should be staked. On the plains with a well distributed rainfall of 50 inches or more the acclimatized West Indian yams require seven to eight months to mature, and have produced at the rate of 8 tons per acre. Mr. Mitchell does not think that the imported yams will succeed at any altitude above 3,000 feet.

POTATO—*Solanum tuberosum*—Linn.

Natural order—*Solanaceæ*.

Gujaráti, *Patáta;* Maráthi and Kanarese, *Batáte.*

Habitat. The potato is believed to be a native of Chili. It was introduced into the United States and Europe in the latter half of the Sixteenth Century. It was brought to India at a much later date probably by the English.

Distribution. This crop is widely grown in India, but not nearly so successfully in the plains as in the hills. Excellent potatoes are grown in the lower slopes of the Himálayas and on the Neilgherries. The Mahábleshwar hill potatoes of the Bombay Presidency are of excellent quality and of large size. Potatoes are grown sparingly in garden lands in all parts of the Presidency. The chief cultivation is in the Poona District which claims 75 per cent. of the total area. Fairly large areas are grown in Ahmednagar, Sátára, Dhárwár, Surat, Kaira and Ahmedabad. The total for the Presidency for 1898-99 was 9,400 acres.

Soils, seasons, rotation mixture.

The potato is always grown alone and generally as a *rabi* irrigated crop. It is essentially a light or free working soil crop. It succeeds best on naturally well drained, deep, sandy loams, such as are found in the garden lands of Surat and Kaira. This crop thrives excellently in the sandy beds of the Sábarmati and other rivers in Gujarát when the streams get low in the fair season. In the Poona District it is rotated with onions, garlic, irrigated wheat, irrigated gram, groundnut and dry crop *bájri*. In Gujarát it takes its place among the numerous other garden crops which are grown.

Varieties.

The varieties in cultivation in Europe and America are exceedingly numerous. There are early, medium and late ripening sorts. They vary exceedingly in size, shape, colour of skin and colour of flesh on section. The skin may be rough or smooth. The eye buds may be numerous or few, and the eyes may be deeply indented or shallow. The colours of varieties are exceedingly various. Many are white or dull yellow, some blue, some all shades of red, one almost black, and one coloured in patches red and white. The colour of the skin may or may not extend into the flesh.

Quality.

Potatoes of fine quality are usually of moderate size (three to the pound), regularly rounded, or oval in shape; skins rough. Eyes shallow and not numerous. The flesh on section should be white or creamy white. A yellow fleshed potato is usually inferior in quality and waxy in consistence when boiled. A white fleshed potato, if of good quality, should crack when boiled (burst its jacket), and, when peeled, should present a granular or mealy appearance.

Varieties which have long been cultivated are degenerated and become more and more liable to disease.

The seedsmen and gardeners of Europe and America produce new varieties annually. Such new varieties are obtained by cross fertilization and by propagating from the true seed. They are less subject usually to disease than varieties which have been long cultivated. Potatoes are usually cultivated from cuttings or sets obtained by subdivision of the tuber. If this method of propagation is carried on for a number of years, any variety will degenerate, and become more and more susceptible to disease. This degeneracy may be arrested or postponed by change of soil, change of climate, change of district. Ultimately, however, the variety deteriorates to the extent that it is not worth cultivating, and a new sort must be obtained.

The propagation of new varieties.

In temperate countries the potato produces flowers freely. In the plains in India potatoes rarely produce flowers. By artificial cross fertilization a European gardener often fertilizes the flower of one variety with the pollen of another. The fruit which is produced will contain hybrid seed. The fruit of the potato is provincially called a plum. New varieties are obtained from the seeds enclosed in the plum.

The plums are allowed slowly to decay. The decayed pulp is washed away, and small white seeds are left behind. New varieties are obtained from these seeds. The seeds should be artificially germinated in folds of blotting paper, kept moist, but not too wet. As each seed is seen to strike, it should be gently removed and planted, in India, in a flower pot containing well manured, fine, sandy soil. The flower pots should have free exposure, but be protected from heavy rainfall or severe weather. The seedlings, although protected as described, should otherwise be grown under as natural conditions as possible. Only a few seedlings out of many thousands are usually found useful for continued cultivation. The most vigourous growing and healthy should be selected. These produce in the first year small tubers, varying in size from a pea to a small marble. These tubers, if planted under favourable conditions, produce larger tubers in the second year. In three or four years by careful cultivation potatoes of natural size may be got.

The Poona method of cultivation.

The soil is mixed black, and the field is usually fallowed during the rains. Two or three ploughings are given between June and September. Old farm yard manure at the rate of thirty to forty cart loads (15 to 20 tons) per acre is applied, and evenly spread before the third ploughing. The bladed harrow is afterwards worked. The manure is thus freely mixed through the soil, and a fine tilth obtained to a depth of 6″ to 8″.

Potatoes are ready for planting when the eye buds are freely started into growth. Tubers of medium size are selected for sets, and each is cut into three or four pieces. 900 lbs. to 1,100 lbs. of potatoes furnish sets sufficient to plant an acre. The sets are planted in the furrows made by an ordinary country plough. The plough works about 4″ deep. The sets are planted 7″ to 8″ apart, and are covered by the soil moved in making the next furrow. The furrows are 9″ to 10″ apart. Beds are formed along the line of furrows 3½ feet wide. If the surface of the field is fairly level, the beds extend the whole width of a small field ; if the surface is uneven, the beds are of variable length. A wooden hoe is used to smooth the surface of the beds and form the ridges which divide the beds from each other. There are four rows of potatoes in each bed. The crop is kept clean by frequent hand weeding with the weeding hook (*khurpa*). Irrigation is given every eight days. The water is directed into each bed in turn, and should flow slowly from the higher to the lower end of each. The crop is planted in October.

The seed rate.

Harvesting.

In March the haulms begin to wither and turn brown. Water is now withheld for a fortnight or three weeks. When the soil is sufficiently dry, a plough is used to raise the crop. It is first worked along the rows. The tubers which are exposed are gathered by women and

children. The field is next cross ploughed, and any exposed tubers again gathered. The field is ploughed a third time diagonally, and this exposes all or nearly all the tubers on the surface.

Sorting for market, &c.

The potatoes are sorted into three sorts when gathered—(*a*) large, (*b*) medium sized, (*c*) small and diseased. The large potatoes are sold, the medium sized potatoes reserved for seed, and the small, &c., used for home consumption. Those which are stored are exposed under shade until quite dry.

Outturn value.

A fair average crop tested in the Poona District in 1892-93 by the writer gave the following outturn, &c., results :—

Local Estimates in Annas.	Outturn per Acre. Lbs.	Value per Acre. Rs.
12 (average crop)	10,230	201

Cultivation in Gujarát.

The preparatory tillage and the amount of manure given are much the same as already described. A fine deep tilth is necessary, and is generally obtained. The last tillage operations before planting are to form ridges and furrows, about 15″ apart, with a plough, and draw deep cross furrows with the plough, 10 feet apart, for water channels. A hand spade is used to form water compartments about 10 feet square. The manner in which this is done has already been fully described under sweet potatoes and other crops. Pits 3″ deep and 9″ apart are dug in the furrows. A set is planted in each, and carefully covered. The beds are immediately watered.

Seed rate.

Italian potatoes which are imported annually are extensively planted in the Surat District, and grow particularly well. The Italian potatoes are fairly large. They are cut up into sets for planting, and 1,400 to 1,600 lbs. per acre are required. The local varieties are much smaller, and of these 1,000 lbs. provide sufficient sets for an acre.

Culture during growth.

Hand weeding with the *khurpa* must be early attended to. As the young plants grow, they are earthed up by hand by splitting the ridges into the furrows. This is done gradually, and, when complete the plants which originally occupied the furrows now grow on ridges, or the beds are left flat.

Harvest.

The crop if planted in October is ripe in March, and is then dug out by hand with a medium sized, blunt pick.

Outturn and value.

An excellent crop of Italian potatoes was tested in a rich garden village in the Surat District by the writer in 1893-94, and gave the following results :—

Anna Estimate.	Outturn per Acre. Lbs.	Value of Outturn per Acre. Rs. a. p.
14 (12 average crop)	15,321	384 2 0

Improvements in cultivation suggested.

I am not sure that the Surat method of growing Italian potatoes can be improved upon in the plains, particularly if, as is occasionally done, the plants are properly earthed up during growth. The short distance between sets and between furrows will strike a European agriculturist as being too small. The heat of India in the plains forces potatoes even in the cold weather prematurely to maturity, and the tubers are necessarily smaller than those produced in a more temperate climate. The closeness of planting need, therefore, not be seriously questioned. The advantage of growing potatoes in ridges rather than in furrows or in flat beds cannot, I think, be disputed. The plant luxuriates naturally on sunny slopes and well drained situations, and it is reasonable to suppose that it cannot thrive properly in the flat irrigated beds in which it is usually grown in India. In any case I believe that indigenous varieties if planted in beds are more subject to disease than if planted on ridges. As regards newly imported good varieties there can be no doubt that the ridge system of planting is best. There is, further, no doubt that the small cut sets used by native cultivators induce weak growth and that larger cut sets or, better still, medium sized whole potatoes produce more vigourous growth and better crops. An experiment in 1892-93 conducted by the Bombay Agricultural Department gave the following results in comparative plots :—

The ridge and furrow system of planting.

The value of new varieties.

Whole sets better than cut sets.

	Seed rate Per Acre. Lbs.	Outturn Per Acre. Lbs.
Cut sets...	... 1,563	10,065
Whole sets	... 1,437	13,509

Whole sets should be $1\frac{1}{4}$" to $1\frac{1}{2}$" in diameter.

Manure.

The ordinary farm yard manure dressing is not the best application for potatoes. This crop, like its near relatives, tobacco, brinjals, and chillies, is specially benefited by potash manures ; therefore, household ashes and crude nitre might with every advantage be used in top dressing the crop before it is fully earthed up, a moderate application of well rotted farm yard manure being given, as usual, before plantation.

Potato disease.

In the Poona District and elsewhere in India the potato crop became infected with a fungoid disease, about 1890, which was locally called *bángdi* owing to the appearance of a dark ring easily visible in the substance of the potato on section. This disease shows its first effect by a sudden withering of the stems. About an inch below the surface the stem is found stained brown. Decay rapidly proceeds, and extends upwards and downwards along the fibrovascular tissues. It finally enters the vascular tissues of the tuber, hence the observable dark ring. The spores harbour in the soil from year to year owing to rem-

nants of previous crops, and this is a certain source of contagion. The obvious remedy is to grow potatoes at long intervals on the same land, but this the cultivators refuse to do.

Effective remedies

Experiments conducted by the Bombay Agricultural Department proved that certain imported varieties at first resisted infection in a marked degree, but, when cultivated in India for a few years, deteriorated, so that they were not immune. The flushing of the land before plantation with irrigation water containing a weak solution of copper sulphate was proved specific as regards all diseased germs which it reached, but the operation was expensive. 84 lbs. of copper sulphate was used per acre. A crop grown on ridges from whole tubers was found much less liable to disease than a crop grown in flat beds from small cut sets, and this was especially the case if ample room was allowed between plants grown on ridges.

Very good undiseased crops were obtained from newly imported seed on diseased land. The best results were as under:—

	Seed rate. Lbs.	Outturn Per Acre. Lbs.
Sutton's Early Regent ...	1,180	16,871
Do. Windsor Castle...	1,361	14,365

Potato blight.

The potato blight of Europe—*Peronospora infestans*—is not known in the Bombay Presidency. It is a fungoid disease which fructifies on the foliage. The spraying of the foliage with copper sulphate solution with quick lime (*Bouillie Bordelaise*) has curative, as well as preventative, effect. The proportions of ingredients for an acre are as under:—

45 Lbs. sulphate of copper.
22½ Lbs. quick lime.
220 Gallons of water (2,200 lbs.).

The sulphate should be dissolved by hanging it in a coarse cloth or basket in water contained in a wooden vessel. Hot water acts more quickly. The quick lime is slaked in a separate tank, and then stirred into a fine gruel with added water. This should be passed through a sieve into the solution, well stirred, and the remaining water added.

Bouillie Bordelaise is a safe and effective application for any fungoid disease which fructifies on the foliage of any crop.

Storing potatoes.

The crop should be dead ripe when harvested, otherwise the tubers will not keep well. All broken, bruised or diseased tubers should be separated. The potatoes when lifted should be kept exposed for several days under a shady tree or other shade until quite dry. Full exposure to the sun is harmful. Large quantities should not be stored in one heap, particularly if there is any suspicion that some of the tubers may be unsound from undeveloped disease. In Gujarát potatoes are stored in uncovered heaps in the cool central room of the

house. A layer of fine dust taken from the sandy roadways is formed on the floor. Over this the potatoes are heaped and freely mixed with the fine dust. The heap is turned every ten days. Tubers which show signs of decay are removed. The whole stock is sold off before the monsoon. It is very difficult to store potatoes successfully during the rains, because they sprout freely and shrivel up.

Cost of Cultivation, Surat District.

	Per Acre. Rs.	a.	p.
Ploughing six times with a light *hal*	6	0	0
Manure—40 full cart loads	30	0	0
Working harrow twice	0	8	0
Levelling and clod crushing	0	8	0
Making beds and water channels	3	8	0
Digging pits for sets; planting and covering sets	3	0	0
Cost of sets 1,200 lbs. (potatoes dear at planting time)	40	0	0
Hand weeding and stirring surface soil with *khurpa* twice	3	0	0
Irrigation—11 waterings during growth; (one pair of bullocks and three men, steadily employed, will irrigate 4 acres)	32	0	0
Harvesting, digging, sorting, carting, &c. ...	12	0	0
Rs. ...	130	8	0
Outturn, say, 12,000 lbs. at wholesale rate of 60 lbs. per rupee	200	0	0

CAYENNE PEPPER OR CHILLIES—*Capsicum.*

Natural order—*Solanaceæ.*

Gujaráti, *Marcha*; Maráthi, *Mirchi*; Kánarese, *Menshinkái.*

Four species of this genus are known in India, *viz.*:—

Capsicum minimum, Roxb., bird's eye chillie.

Capsicum grossum, Wild, bell pepper.

Capsicum annum, Linn., Goa or red pepper.

Capsicum frutescens, Linn., the shrubby or common chillie.

Only the two last are much cultivated in India.

Habitat. The home of the common Indian variety (*Capsicum frutescens*) is believed to be in tropical America. Chillies were introduced into India in comparatively recent times probably by the Portuguese.

General character of the plant. The plant is an annual. It varies in size according to variety. The varieties of *C. frutescens* grown throughout the Presidency range in height from 18″ to 3′. They are much branched shrubs, with small leaves and very numerous, small, white flowers. The fruits vary in size and colour according to variety. The colour may be dark red, red orange or yellow.

Bombay varieties.

The *Deshi* variety of the Deccan has a small, red, pungent fruit, gradually tapering from a blunt base to a sharp point. The *Deshi* variety of Northern Gujarát is large, thick, irregular in shape, inflated, sometimes curved, not very pungent, and red in colour. A variety with small, red, pungent fruit, similar to the *Deshi* variety of the Deccan, is also cultivated in Northern Gujarát. The *lavengia* variety of Surat has small, orange coloured, very pungent fruit. It takes its name from the Gujaráti word *laveng* (a clove). This variety probably belongs to *Capsicum minimum*. The *bor mirchi* gets its name from its resemblance to the fruit of the *bor* tree (*Ziziphus jujuba*).

Distribution.

The Bombay Presidency area in 1898-99 was 135,000 acres. The Dhárwár cultivation is by far the most important. Belgaum comes next. Khándesh, Sátára, Poona and Sholápur grow 8,000 to 12,000 acres each, Násik and Ahmednagar about 5,000 acres each. In Gujarát the crop is not of much importance.

Season, mixtures, rotations.

The crop is invariably planted in the rains, but, if helped by irrigation, the growth extends into the *rabi* season. Chillies are grown to a large extent alone, but are also planted along the ridges and at the corners of the beds, subordinate to many garden crops, such as ginger, turmeric, potatoes, onions, garlic, &c. In the Deccan chillies are rotated with onions, potatoes, groundnut, irrigated wheat, gram, &c. In Gujarát the crop is rotated with the numerous other garden crops grown, but in particular with brinjals, turmeric, sugarcane and *surans*.

Soils.

The best dry crop chillies are grown on deep retentive black soil. The irrigated crop is grown in the Deccan in mixed black soil. In Gujarát the best crops are got in *besar* (clay loam) soils. The Bombay market is largely supplied with chillies grown without irrigation in the deep black soils of the Krishna Valley.

Cultivation in the Deccan.

The irrigated crop is only grown by well-to-do cultivators who can afford the liberal management which the crop needs. Chillies are grown from transplanted seedlings. The seedlings are raised in a nursery.

The seed bed.

This seed bed is got ready in May. It should be in a sheltered position. The soil should be in a very fine state of tilth when the seed is sown. The seeds are very small, and should, before sowing, be mixed with powdered earth or ashes to secure even distribution. The seedlings should come up thickly, but should not be over crowded, or they will grow tall and weak and not easy to transplant successfully. 1 to 1½ lbs. seed will give seedlings sufficient for an acre. The seed when sown should be lightly covered with soil. The seed bed should be covered with light branches, leaves, or straw to protect the seedlings from the sun. These are delicate at first, and it is therefore preferable

to water by hand rather than irrigate from a channel. They get hardier when about three weeks old, and are ready for transplantation when six weeks old and 6 or 8 inches high.

Cultivation of the field.

The plough should be worked two or three times. The manure (15 tons at least per acre of old farm yard manure) should be spread before the first ploughing. The bladed harrow should be used frequently after the plough until a fine friable tilth to a depth of 4″ is obtained. In a district of light rainfall beds for irrigation should now be formed. In a district of moderate or heavy rainfall this operation should be deferred until the end of the monsoon. The small Deccan variety of chillie should be planted 18″ apart in the rows with the same distance between rows. Three or four seedlings should be planted together, care being taken that the seedlings are lifted from the seed bed without damaging the roots and that transplantation is properly done. The seedlings are best transplanted in the evening in cloudy weather. If there is a shower during night or light rainfall next day, the operation is sure to be successful ; but, if bright sunshine for several days follows transplantation, many of the seedlings will die. These must be replaced as expeditiously as possible. The rows of plants should be accurately straight, so that the bullock hoe can be used for inter-culture if beds for irrigation have not been formed. If the land is laid out for irrigation, the surface soil is stirred, and weeds removed by means of the weeding hook (*khurpa*). When the plants are fairly established, they should be earthed up. A little mound of soil is formed round each clump of plants. During prolonged breaks in the rains irrigation must be given, and, when the rains cease, a watering is necessary every eight or ten days.

Harvest.

About three months after planting, the first fruit forms. If the field is regularly irrigated, the plants will go on bearing for five or six months, and this period may be prolonged by stimulating the plants with a top dressing of castor cake of 600 lbs. to 1,000 lbs. per acre given in September-October. In a district where there is a good demand for green chillies these should be picked three times a month at the beginning of the season and at longer intervals afterwards. Ripe chillies are picked three times or oftener during the fruit season as they mature.

Gujarát cultivation.

The cultivation in Gujarát is somewhat different from that in the Deccan. During the early monsoon the field is ploughed three or four times often enough to bury the manure (thirty cart loads per acre) and produce a good tilth. When the seedlings are 9″ to 12″ high and two months old, they are transplanted into rows 3 feet apart with a like distance between plants. The plants grow to a height of 3 feet,

and require plenty of air space. Three to five seedlings are put in each hill. The bullock hoe (*karabdi*) is used as soon as the plants are fairly established. This implement is worked lengthwise, as well as across the field. Any weeds not reached are removed by the weeding hook (*khurpa*). The surface soil should be moved with the *karabdi* as soon as dry after each succeeding shower of rain. This implement, if yoked with a steady pair of bullocks, may be worked advantageously up to the time the flowers begin to appear. Then the plants should be earthed up, beds for irrigation should be formed, and all tillage should cease.

The crop is prepared for market by laying the pods out on mats to dry in the sun. In the Deccan they are usually exposed on sheet rock near the cultivator's home. When comparatively dry, they are sown up as tightly as possible in coarse sacking in bundles of four or five bushel capacity, and carted to market.

Chillies are used in *chatnis*, pickles and Indian condiments, and also medicinally. Cayenne pepper is made by grinding to a powder the ripe pods of red pungent varieties. Nepaul pepper is similarly obtained from a mild flavoured yellow fruit. Uses.

BRINJAL OR EGG PLANT—*Solanum melongena*—Linn.

Natural order—*Solanaceæ*.

Gujaráti, *Vengan*; Maráthi, *Vánge*; Kánarese, *Badnikái*.

This plant is believed to be a native of Asia (De Candolle). Other authors believe it to be of Arabian origin. Habitat.

It is cultivated all over India, "and is often met with as an escape from cultivation, in which condition it becomes more prickly and more prolific as to the number of fruits." (Duthie.)

The Bombay varieties with large purple fruit grow into much branched shrubs about 3 feet high. The small fruited varieties are not so tall, but have the same branching habit of growth. The leaves have a peculiar greyish green colour. The Bombay field varieties have all prickles. "Leaves ovate, sinuate, or lobed, clothed beneath with stellate hairs, flowers bluish, arranged in extra-axillary cymes, usually only the lowest on the cyme becoming fertilized, fruit or berry, round, oval or elongate, cylindrical." (Duthie.) General Character of the plant.

The commonest variety has very large purple fruits, tapering gradually from the attachment to flower stalk to a round, full, thick end. Well grown fruits are each 10″ to 12″ long. Another variety has very large, round, purple fruit, about the size of a pumalo. A favourite variety in the Surat District has nearly round or slightly oval, small, purple fruit, about the size of an orange This is considered Bombay varieties.

a more delicate vegetable than the others, and commands a higher market rate. The three varieties named represent the usual sizes and shapes of brinjal fruit, but, according to variety, the colour varies from purple to variegated purple and green or yellowish green, faintly marked with purple.

Distribution. The crop is grown sparingly throughout the Presidency in all garden lands, but the chief cultivation is in Gujarát, particularly in the *goráḍu* or *besar* garden lands of Kaira and Baroda Territory.

Soils, season, rotation, mixtures. Brinjals, like chillies, grow most successfully on the heavier descriptions of soils which can be successfully irrigated. The crop is always grown alone and in the rains. Its growth extends into the *rabi* season if helped by irrigation. The rotations are the same as described for chillies.

Cultivation. The seed bed. The crop is grown from transplanted seedlings. The seed bed is got ready in May, and should be carefully prepared and liberally manured. The seed should not be broadcasted too thickly. The seedlings require more room in the seed bed than chillies. They are ready for transplantation when six weeks to two months old. They should then be well rooted, with stout stems, and about 6″ to 8″ high.

The field. A heavy dressing of manure is necessary, not less than 20 tons old farm yard manure per acre or a less quantity if supplemented by a subsequent top dressing of oil cake, nitre or other quick acting concentrated manure. The same preparatory tillage as described for chillies is required.

The seedlings of the large varieties are transplanted two together in a hill, 3 to 3½ feet apart in the rows and the same distance between rows. The smaller varieties should have a space of 2½ feet between plants in each direction. The interculture for brinjals and the weeding and earthing up should be done precisely as described for chillies. A top dressing of nitre or castor cake at the rate of 500 lbs. of the former or 1,000 lbs. of the latter per acre will be found very beneficial. This should be given round the plants before they are earthed up. Beds for irrigation and regular watering when required should be arranged for in the same way as described for chillies.

Harvest. The crop should begin to bear in October, and continue in bearing for several months. The fruits in a well nourished, vigorous crop form and ripen with great rapidity, and should be plucked every second or third day.

The following tabulated results show that nitre as a top dressing has a remarkable effect on the brinjal. It is possible that the potash of the nitre was as effective as the nitrogen. We know that potatoes, tobacco and chillies—near relatives of brinjal—are specially benefited

by potash manures. The results are from comparative plots on the Poona Government Farm :—

Kind of Manure.	Quantity of Manure per Acre.	Outturn per Acre.	Cost of Cultivation per Acre.	Value of Outturn per Acre.	Remarks.
	Lbs.	Lbs.	Rs. a.	Rs. a.	
Dried Fish	1,451	16,322	138 6	325 5	Comparable.
Nitre	433				
Dried Fish	1,451	11,400	79 9	227 3	
Dissolved bones ...	1,651	11,700	224 11	233 2	Comparable.
Nitre	433				
Dissolved bones ...	1,651	7,882	165 2	157 2	
Castor-cake	1,488	15,080	182 11	300 10	Comparable.
Nitre	544				
Castor-cake	1,488	7,546	81 14	150 7	

The variation in cost of cultivation between plots was almost entirely due to difference in value of manures applied and the difference in cost of gathering the fruit. Nitre is exceedingly dear in Poona. Yet for this crop a moderate application will apparently pay well.

The brinjal is a risky crop in districts of heavy rainfall. The young plants die in heavy soil during heavy rainfall. This plant, like chillies, is subject to a curious malformation of the branches and leaves. Affected plants produce no fruit. A risky crop.

THE ONION—*Allium cepa*—Willd.

Natural order—*Liliaceæ*.

Gujaráti, *Kándo*; Maráthi, *Kánda*; Kanarese, *Ullágadde*.

The onion has been cultivated from very ancient times. It is found wild in Afghanistan and Beluchistan, and may be indigenous also in Palestine. (De Candolle.) The plant is largely cultivated all over India, and is an important market garden crop in the Bombay Presidency. Habitat.

The area in the Presidency is not separately returned. The crop is grown to some extent in all districts. The cultivation is most important in the garden lands of Gujarát, in the Dhulia Tàluka of Khàndesh, and in the Khed and Junnar Tàlukas of the Poona District. Distribution Bombay.

Onions succeed best in free working, well drained soil of fair depth. The mixed black soil of the Deccan, on which other irrigated crops are grown, suits the crop very well. Soil's.

Season. Mixtures. Onions are only grown alone, and always as a cold weather irrigated crop.

Rotations. In Gujarát the crop is rotated with the numerous other irrigated garden crops. In the Deccan it is rotated with potatoes, chillies, groundnut, irrigated wheat and gram, garlic, sweet potatoes, &c.

The land is occasionally rested from irrigation. Then dry crops of *jowári* and *bájri* with subordinate mixtures are grown.

Varieties. Three chief varieties are grown in the Presidency: a large red and a large yellow variety and a smaller pure silvery white variety. The common red variety is very strong flavoured. It has a red tinge inside, but towards the centre the bulb is nearly white. The yellow onion is also strong flavoured. It has creamy white flesh. The white onion is extensively grown at Dhulia, and its cultivation is extending in other parts of the Presidency. It is mild flavoured. The smaller bulbs are suitable for pickling, and there is a considerable and increasing export trade in this variety on account of its fine mild flavour.

Introduced rieties. It is probable that these varieties were obtained originally from imported seed. It is, however, difficult to successfully import seed of good vitality. European seed ripens in the autumn, and therefore cannot be imported into India soon enough for the crop of that year; and onion seed loses vitality so quickly that in the following year few, if any, of the seeds would germinate. Possibly, however, sound seed might be obtained by planting imported bulbs, and the experiment is certainly worth trial.

Onion Seed. Onion seed is produced in India as follows:—Well developed bulbs are selected. These before planting are cut in two with a knife; the top part to the extent of a quarter of the bulb is cut clear away. The "but" ends are planted 6″ apart in beds, the soil of which by previous tillage has been thoroughly well prepared and liberally manured. Several shoots with flowering heads should spring from each bulb. These ripen in February-March, and seed thus obtained will keep good until required for sowing for the main crop in the following September-October.

The seed bed. The main crop in India is raised from transplanted seedlings. The seedlings are grown in a seed bed. There is a common English saying in regard to fine tilth, *viz.*, "Fine as an onion bed." This saying holds good all the world over. The onion nursery must be well dug, liberally manured, and be in a thoroughly friable condition. For this reason land which is distinctly loamy makes the most satisfactory seed bed. The seed should be thickly broadcasted in September, and lightly covered. 15 lbs. of sound seed properly distributed in a nursery will give seedlings sufficient for an acre of transplantation. The seed bed

should be carefully weeded, and if the seedlings are too thick they should be thinned out, so that all grow into healthy, vigorous plants, such only being suitable for transplanting.

Cultivation of the field.

The preparatory tillage should be careful. Onions are sometimes grown after a rain crop of *bájri*. Well rotted farm yard manure at the rate of at least 15 tons per acre should be spread on the *bájri* stubble. The plough should now be worked two or three times, and then the bladed harrow. The stubble should be collected and burnt. Beds for irrigation should be formed when the surface soil has been worked to a smooth, friable consistence.

Transplanting and subsequent cultivation.

The seed beds two or three days before transplantation should be freely irrigated. The soil is thus softened, so that the seedlings are easily uprooted. Half the length of the leaves or shoots should be clipped off, also long rootlets. If the soil is mixed black, the beds are generally irrigated before transplantation, and the seedlings are pushed singly into the soft mud about 4″ apart. If the soil is a free working loam, the seedlings are carefully planted before the beds are irrigated; but, as each bed is finished, water is admitted at once. A second watering should be given four days after the first, and subsequently at regular intervals of eight days. Hand weeding should be given as required. A top dressing of ashes or of castor cake crushed to a fine powder has an excellent effect. The ashes or oil cake should be worked into the soil with the weeding hook (*khurpa*), weeds being removed during the same operation. The seedlings are generally transplanted late in November or early in December, and the crop is ready for lifting in March-April. It is ripe when the tops begin to turn yellow and fall down. The bulbs may be lifted about ten days after the last watering. They are easily uprooted either by hand or with a very light pick. They should be at once sorted and cleaned. The roots and tops are removed by means of a sharp sickle. A woman by means of her toes and foot holds the handle of the sickle securely on the ground. The blade of the sickle is presented vertically, and the woman using both hands presses each onion in turn against the sharp edge, first removing the roots, then the top.

Top dressing

Harvest.

Outturn and value.

Two tests taken in 1894-95 on excellent crops at Khed (Poona District) gave the following results :—

	Outturn of Bulbs per Acre. Lbs.	Value per Acre. Rs. a. p.
1st Test	35,022	235 0 0
2nd Test	34,514	228 0 0

The onions in the above tests lost by dryage 11 per cent. during 18 days' storage, and this is allowed for in the outturn figures. The whole

sale rates for onions in the Poona District are generally low, the area being considerable and the produce much more than is required for local demand.

A curious method of cultivation.

Dhola (white) onions are grown in rather a curious way in the Surat District. The large onions of a crop are sold when lifted; the smaller are stored until the following November, and then planted. Each grows into a large single bulb or by sub division into several small bulbs.

About 1,000 lbs. of small dry onions are sufficient to plant an acre. The field is prepared carefully and laid out into beds for irrigation. Small pits are dug 6 to 8 inches apart. The single small bulbs are planted one in each pit and carefully covered. After the first watering, the bulbs just show at the surface. Onions planted in this manner, if left alone, would, in due course, produce seed; but all flower stalks are removed, and as the crop ripens, bulbs are produced. The crop is harvested comparatively green. Each onion has, when lifted, a coarse neck and a good deal of green top. The tops are cut off close to the bulb, and left in the field to rot. These bulbs must be left fully exposed to the air for some time before being stored. They lose at least 25 per cent. of weight by dryage.

Cost of Cultivation, Surat District.

	Per Acre. Rs.	a.	p.
Manure—30 loads ordinary manure and spreading	16	0	0
Preparatory tillage—six ploughings with *hal*, two harrowings and levelling with plank roller	6	8	0
Making beds and water channels and levelling beds	3	8	0
Cost of seed and seed bed	8	0	0
Transplanting seedlings	9	0	0
Weeding and loosening surface soil with *khurpa*	2	8	0
Irrigation—eighteen times...	54	0	0
Digging up, removing tops and roots	9	0	0
Rs. ...	108	8	0

GARLIC—*Allium sativum*—Linn.

Natural order—*Liliaceæ*.

Gujaráti, *Lasan*; Maráthi, *Lasun*; Kanarese, *Belloli*.

Habitat.

De Candolle says that garlic is only found wild in the desert of Kirghis of Sungari.

General character.

This plant is perennial and closely related to the onion. "Its true stem which is much reduced gives off roots from the base, and supports as cauline appendages the overlapping scales (old leaf bases) which are thickened below and bear in the axils small bulbs or cloves. These closely imbricating scales, together with the cloves and the

reduced stem, form the bulb. The flowering stem or scape emerges from the centre of the bulb, and bears a few flowers, the majority being replaced by diminutive bulbs." (Duthie.)

The leaves are long, lanceolate, flat, sharp pointed. The sheaths enclose the lower half of the stem. The plants in a good crop grow to a height of 18". The flowers are small and white.

Distribution. Garlic is cultivated all over India. In the Bombay Presidency the area in 1898-99 was 7,500 acres. The most important centres of cultivation are Belgaum, Dhárwár, Násik, Poona, and Sátará.

Season, soils, rotation, mixtures. Garlic is generally grown alone and always as a cold weather irrigated crop, and does best under precisely the same conditions of cultivation, on the same kinds of soils and with same rotations as suit onions. These conditions have already been described in detail.

Cultivation. The field is prepared, manured, and laid out for irrigation in the same way as for onions. The crop is propagated from the cloves. These are broadcasted very carefully in the beds in October, and lightly covered with soil. In a bed 10ft. square $1\frac{3}{4}$ lbs. of dry cloves should be sown. This gives a seed rate of about 700 lbs. per acre. The crop should be top dressed with manure, hand weeded and watered in the same way as described for onions. It ripens when the leaves turn yellow $4\frac{1}{2}$ to 5 months after planting. The bulbs are lifted and prepared for market like onions.

Outturn value. A good crop yields 8,000 lbs. to 10,000 lbs. per acre, and is worth at ordinary wholesale rates about Rs. 250 per acre.

COTTON—*Gossypium.*

Gujaráti, *Kapás;* Maráthi, *Kápus;* Kanarese, *Hatti.*

A genus of the natural order *Malvaceæ*, which is widely distributed in both hemispheres.

Habitat. Cotton is chiefly grown in tropical or subtropical countries, but its cultivation extends south of the equator as far as the Cape of Good Hope. Various species are wild in India. The crop is very extensively grown in India. The annual area is probably about 14,000,000 to 15,000,000 acres.

Distribution in the Bombay Presidency. The Bombay area in favourable years approaches three million acres, but contracts considerably when early rains are deficient or the season is otherwise unfavourable. Ahmedabad, Broach and Surat are the only cotton growing districts of importance in Gujarát. In the Deccan the Khándesh area is most extensive. But the crop is also important in Ahmednagar and Násik. In the Karnátak the crop is extensively grown in all the three collectorates, but most extensively in Dhárwár. No cotton is grown in the Konkan.

Soils; season. The crop succeeds best on black soil of fair depth with a well distributed rainfall of 30 to 40 inches. It is grown entirely as a

dry crop. The most suitable soil is known as "black cotton soil." Such soil may be 5 feet or more in depth as in Ahmedabad, Broach, Surat, and parts of Khándesh, Dhárwár, Bijápur, &c.; but the crop is also extensively grown on much shallower black soil. This is certainly the case throughout the Deccan and Karnátak. In Khándesh a considerable proportion of the cotton area is found on mixed black and reddish soils of no great depth. In fact, throughout the Deccan and Karnátak the crop is grown on the better classes of soils found in the rolling uplands, as well as on the true "black cotton soil" which is found usually in lower lying vales or plains.

Mixtures. The crop is chiefly grown alone. In Broach, on very deep retentive black soil and with sometimes a rainfall heavier than the crop needs, rice in the same rows or in separate rows is often subordinate to cotton. A slight sprinkling of coriander and other condiments of similar class is often seen in cotton fields and in patchy crops. Sesamum is sown to fill vacancies, sometimes also gram (*Cicer arietinum*). These crops are chosen, because they are likely to succeed even if sown when the *kharif* season has well advanced or the *rabi* season begun. The perennial *rozi* cotton of Kaira, &c., is on *gorádu* or sandy loam soils, grown always as a row crop with *bájri*, pulses, &c.

Rotations. *Jowár* is the principal rotation crop with cotton, but the ordinary cotton-*jowár* rotation is extensively modified according to district and season. Thus wheat as a dry *rabi* crop is grown extensively on the cotton soils of Ahmedabad. *Lúng* and a mixed crop of *tuver* and sesamum as *rabi* crops are grown on cotton land in Broach, especially in years when the early rainfall is too heavy for cotton. Sesamum and wheat, as well as *jowár* are regularly rotated with cotton in Surat. In the Deccan the rotation in lands which grow cotton is still more extended. *Jowár* is here also the chief crop, but *bájri*, sesamum, linseed, gram and wheat are also taken, as the character of the soil and the season may determine. In the Karnátak the cotton-*jowár* rotation is perhaps more strictly adhered to than elsewhere, still we have here also variety in such crops as wheat, Italian millet, castors and safflower, the latter, however, generally occupying separate rows with *jowár*.

Cultivation in Broach.

The general character of the soils. The cotton soil of the district is deep and black, and rests on a deep substratum of yellow earth. The soil cracks freely in the fair season.

The value of rotation and special tillage and effect of season. It is very deep and very retentive of moisture. The annual rainfall varies between tálukas from 30 to 40 inches, but over the greater part of the district exceeds 35 inches on an average, and in occasional years is as high as 60 inches. Generally speaking, the cotton fields

during the early monsoon rainfall get sodden with heavy rain, and are more or less unworkable for a time. The crop is sown as early as possible after the monsoon sets in, but, as a rule, two or more sowings are required before satisfactory germination is secured. This is entirely owing to the effect of heavy rainfall on a very retentive soil. The seed is, therefore, generally more successfully sown in July than in June. Usually the same field grows cotton every second year. In intermediate years the field may be fallowed, or grow one or the other of the crops with which cotton is rotated. The character of the season determines to some extent the rotation crop chosen by the cultivator. The system of fallowing (*váshil*) is extensively employed in Broach, and an exceptionally good cotton crop is generally got after a year's fallow. It is generally recognized that cotton on the deep fertile black soil of Broach and to a less extent in other districts is more benefited by thorough tillage than by applied manure. The fallow tillage is thoroughly done, and, when the monsoon rain comes, the soil of a *váshil* field is clean and friable to a considerable depth. It soaks up the rain as it falls, and, when dry enough after rain, provides a seed bed in a perfect state of tilth. Cotton derives more benefit from residues of manure left in a soil than from manure directly applied. Cotton soil rarely gets manure oftener than once in three years in Broach or elsewhere. Fifteen loads per acre may be considered a full average application. If manure is used, it should be in a thoroughly decayed condition, and by preference should be applied before the rains come. It can be mixed with the soil by freely using the bladed harrow (*karab*). It is a risky operation on deep black soil to apply manure after the rains set in. A passing shower may interrupt the work, and the tillage required to mix the manure with the soil may delay sowing. Sowing should be pushed on vigourously when the soil is in a suitable condition, because a heavy shower of rain may interrupt field work for days. *Váshil* fields can be more expeditiously sown than other fields, and this is one reason why the system of fallowing in Broach answers so well for cotton.

Preparatory tillage.

Tillage begins usually in the hot weather by collecting and burning the stubbles of *jowár* or other previous crop. The preparatory tillage is least costly when cotton succeeds *láng* (*Lathyrus sativus*). The *láng* when harvested leaves the field in as clean a condition as if it were fallowed. The soil, although it has cracked to a considerable extent, is on the surface fairly loose and friable when the *láng* is reaped. Tillage should begin immediately. If the harrow is freely worked during the hot weather, a very fine state of tilth is produced. Cotton may on such land be sown in June as soon as sufficient rain falls. If cotton is taken after *jowár*, more costly preparatory tillage is required. A heavy

harrow should be used during the hot weather to grub up stubbles, scrape the surface, and fill in the cracks. When the first monsoon showers moisten the soil a span deep, the plough should be used and after it the harrow. The preparatory tillage should be completed as expeditiously as possible, because in Broach as in all districts, except the Karnàtak, it is most important to get cotton sown early. Two ploughings and two or more harrowings may be required before the seed is sown, and usually also it is necessary to use the *samár* (plank roller) to level the surface. Sowing should, if possible, be completed in June.

Preparing the seed for sowing and sowing the seed.

When cotton is sown alone, the seed is drilled in rows 22″ to 26″ apart. The seeds, although carefully ginned, retain some lint and fuzz; therefore, they cling together, and, in consequence, require special preparation for sowing. The seed is prepared for sowing by mixing it with a thin plaster of cowdung, mud and water, and rubbing the plastered seed on the close network of a *chárpái* (native bedstead). This treatment makes it possible to pass the seed when dry ready through the seed bowl and tubes of an ordinary country seed drill. The bamboo tubes are larger in diameter for cotton than for ordinary grain crops. The seed rate varies. 5 lbs. per acre would be ample if all the seed germinated and was equally distributed; but, as the seed is cheap, three times the above quantity is usually sown. Two harrows follow one drill to cover the seed and smooth the surface. When young, the seedlings are very delicate and liable to damage by insects and also by heavy rain. If the seedlings are damaged to a considerable extent before they produce true leaves, the crop should be re-sown, especially if the season has not far advanced.

Interculture and thinning out the plants.

The crop is generally intercultured with the bullock hoe and hand weeded once or twice. Interculture begins when the seedlings are about 4 inches high. When they have made some further progress, the weaklings are thinned out. The plants are left about 18 inches to 2 feet apart in the rows, but this only in the case of a field in good condition and in an early sown, promising crop. If the young plants are backward, and stunted from any cause, they are left much closer together. Cotton must be kept quite free from weeds, or it will not thrive. The plough is passed between the rows in September or October. This is the final tillage operation. It has the effect of preventing deep black soil from cracking, and therefore has also a tendency to conserve the moisture in the soil. Interculture of any kind would do harm when the flowers appear, because it would interfere with proper fertilization.

Rice subordinate to cotton.

It is a common practice in the very deep black soil of Broach to grow cotton and rice mixed. The practice is unknown in any other part of the Presidency. This practice safeguards the Broach cultivator. Cotton seedlings are liable more or less to be damaged and destroyed

by heavy downpours of rain early in the season on retentive deep black soil. Rice usually flourishes in such rainfall. The rice generally occupies the same rows as the cotton, and when alone occupies an intermediate row. The cotton rows are generally 28 inches apart, but if the field has recently been manured and is therefore in good condition, the distance may be as much as 3 feet. With a heavy rainfall the rice does better than the cotton. With a light or moderate rainfall the cotton does best. It is seldom that the season suits both crops. The rice is ready for harvest in October. An average outturn of rice subordinate to cotton in a good field will range from 240 lbs. to 320 lbs. per acre of grain. If, when the rice is reaped, there is a good deal of moisture left in the soil, the cotton plants branch out vigourously, and if the field is in good condition, and if tillage operations (especially weeding) have been properly attended to, then a good cotton crop may be expected.

The flowering period.

Broach cotton begins to produce flowers in October-November, and the outturn is considerably affected by the character of the weather during the flowering period. This period in a season of favourable late rain lasts until January. A few flowers appear even later. Cloudy weather during this period is disastrous, sometimes in causing imperfect fertilization or at least in causing immature bolls to fall from the plants in large numbers.

Harvest.

Cotton picking usually begins in January, and lasts until March and sometimes to April. The crop is picked at short intervals, because the cultivators fear that their fields will be robbed at night. Four or five pickings are necessary when there is no risk of night pilfering. The second and third pickings are usually the most important ones. The lint can be picked clean in the early morning owing to the effect of dew on the foliage. Later in the day the mature stipules and leaves get dry and crisp owing to the heat of the sun, and stick to the lint. Therefore, picking ought always to be done in the morning. But, generally, the work is carried on throughout the day. It is done by women and children. They work more deftly than men. Contract rates are usually paid, *viz.*, 2½ annas to 4 annas per maund of 38½ lbs. —the cheaper rate for a good crop. These rates only apply to the more important pickings. The minor pickings are usually accomplished by the cultivator himself and his family.

Outturn. Broach District.

In 1898 I took several tests on what I considered average crops of cotton on well cultivated fields, the soil in each case being superior black cotton soil. In each field rice was subordinate to the cotton, but was not tested. The outturn of rice may fairly be estimated as worth Rs. 7 to Rs. 10 per acre.

The cotton outturn results worked out as under :—

Field.	Local Anna Estimate of Crop. (Full Crop 16 Annas.)	Outturn of Seed Cotton per Acre. Lbs.	Value of Outturn.	Assessment per Acre.
			Rs. a.	Rs. a. p.
1st	14	446	30 9	5 7 0
2nd	14	400	27 7	5 6 10
3rd	12	378	25 15	5 10 0
4th	10 or 11	334	22 14	5 2 11

Marketing the produce.

It is the invariable practice in the Broach District and in most cotton growing districts to sell the seed cotton produce (lint and seed) to the owners of ginning factories. It is sold by the *bhár* of 24 maunds of 38½ lbs. The *bhár* is, however, a variable weight in different tálukas. A *bhár* of the weight referred to was, in 1898, worth Rs. 75 to Rs. 85, but is variable in value in different seasons and for different qualities. Cotton picked in dirty condition commands a smaller price than clean cotton. Again, if the lint is seriously discoloured and damaged by boll worm, as it too commonly is, a poorer price is obtained.

Broach and other Bombay varieties. Professor Middleton's descriptions.

The *Deshi* or *Kánhami* cotton of Broach as cultivated in Broach and Surat is a pure, unmixed variety, and is probably the best long stapled cotton in cultivation in India. Another variety—*goghári*—is in general cultivation in Broach, but, although occasionally grown from pure seed, is usually mixed with *Deshi*. *Goghári* cotton is gaining ground, because it is hardy, vigourous growing and safe to yield a good outturn in an ordinary season. It gives a high percentage of lint to seed. The lint is whiter than *Deshi*, but is shorter and coarser. The reader is referred for full descriptions of these and other Indian cultivated cottons to Professor Middleton's excellent note printed in Agricultural Ledger No. 8, 1895. He describes all the Bombay varieties, and gives sound advice regarding possible methods of improvement.

Improvement by selection of seed.

The two varieties of cotton referred to suit the conditions of soil and climate in Broach and Surat, and their maintenance as pure varieties is important. Their improvement by selection of seed continued from year to year is still more important. If careful selection of seed is practised, and if the cultivator takes the trouble to hand gin his seed at home (as is done in Khándesh), there is hope that the lint will be improved in quality, that the outturn per acre will increase, and that boll worm which now does such extensive damage in the cotton fields of Broach and Surat will do less harm. In specially selecting the seed, cotton should be picked from the best sound bolls of large, healthy plants of branching habit of growth, each plant having a large number of bolls. Seed should not be taken from plants on

which any of the bolls are affected with boll worm. Such bolls can easily be detected on account of the stained colour of the lint. If seed affected with boll worm is used, there is grave risk of the crop grown therefrom being affected. It is well known that boll worm exists from season to season, the larvæ feeding by preference on the kernels of cotton seed. As a further precaution against boll worm attack, cotton seed should, before it is prepared for sowing, be steeped for five minutes in a ½ per cent. solution of copper sulphate, and afterwards dried in the sun. The Broach and Surat cultivators get their seed under existing conditions almost entirely from the ginning factories, and it is easy to conceive that impure seed tainted with boll worm larvæ may thus be obtained.

Cultivation in Surat.

The cultivation in Surat does not differ materially from that in Broach. The same *Deshi* variety is the principal crop in both districts.

The general conditions of soil and climate and rotation practised.

In Surat, cotton is confined to the northern tálukas having a moderate rainfall. The average rainfall is perhaps slightly heavier than in Broach. But Surat cotton soil is not so deep or so dense, and, except in lowlying water logged situations, there is less risk of cotton seedlings being destroyed by heavy rain. The rotation crops with cotton are in Surat mostly *kharif* crops, whereas in Broach they are *rabi*. *Jowári* is the principal rotation crop, and it has always a subordinate mixture of white *tuver*. Here and there the rotation is extended by taking sesamum or mixed sesamum and *tuver* and in one táluka wheat. Rice is never sown with cotton in Surat. If there are vacancies in cotton fields due to irregular germination, such are generally sown with sesamum.

Tillage.

Cotton follows *jowár* usually. The *jowár* stubble which is generally of considerable length is removed in the fair season and used as fuel. The harrow is generally used once or twice before the rains. The field is ploughed once after the first fall of rain, and further worked with the harrow once or twice. About 15 lbs. seed per acre is drilled in rows 18 to 24 inches apart. Two harrows follow one drill to cover the seed and smooth the surface. The crop is intercultured two to four times with the bullock hoe and hand weeded once or twice. The plough is passed between the rows in September or October.

Average outturn.

I do not think that on an average the cotton crop of Surat yields so well as in Broach. Seventeen special crop experiments taken in the Surat District in 1895-96 give the following averages :—

Seed rate per Acre.	Outturn, Lint and Seed per Acre.	Value of Outturn per Acre.	Assessment per Acre.
Lbs.	Lbs.	Rs. a. p.	Rs. a. p
15	361½	31 5 3	5 4 4

A comparison with croptest results from Broach will show that the price of cotton depreciated considerably between 1895-96 and 1897-98.

Cultivation in the Karnátak.

The general character of soil, climate and tillage.

The cotton lands of the Karnátak, especially in Dhárwár and Belgaum, are subject to the influence of two monsoons—the South-West between June and October and the North-East or Madras monsoon between October and December. It is essential that the cotton crop should be sown at a time which will bring it to maturity when rain is not expected. The Dhárwár varieties, if sown in June as in other districts, would ripen in the middle of the North-East monsoon, and the lint would be seriously damaged by rain. As a rule, cotton sowing begins in August, generally in the latter part of the month. It may extend to September. In ordinary seasons the rainfall before August will have thoroughly soaked the soil, and have given the cultivator full opportunities for giving the necessary tillage. Fields which are infested with deep rooted grasses like *kunda* or *harióli* are ploughed with the heavy plough in the hot weather. The land is turned up into huge clods. In badly infested fields the patches of *kunda* may be hand dug. This is a tedious and costly operation. The clods crumble after the first fall of rain. Then a heavy bladed harrow is used, and tillage by means of this implement is continued during June and July. Fields which are fairly clean are ploughed with a light plough after the rains begin and not before. They are afterwards worked at intervals with the harrow to keep down weeds and to prepare a satisfactory seed bed. At sowing time the soil should be dry on the surface, but moist below, and smooth and friable to a depth of about 3 inches. The seed is drilled in rows which are 18″ apart. The seedlings are not thinned out to the same extent as in Broach and Surat. They are left comparatively close together in the rows, and in Dhárwár fields, as ordinarily cultivated, the plants are puny as compared with those in the best fields of Broach. The Dhárwár crop is intercultured and hand weeded as carefully as in Broach, and the description given for Broach applies to the Karnátak, but chiefly to Dhárwár.

Varieties.

Two varieties are in common cultivation—the indigenous variety commonly known as *kumpta* (presumably because exported from that seaport before railway communication was introduced) and acclimatized American, commonly known as "Saw-ginned Dhárwár." The indigenous *kumpta* closely resembles Broach *Deshi*, and produces lint of fine quality.

Exotic varieties.

The exotic was introduced by Government in 1842, and in the Karnátak its cultivation rapidly extended, and has been more or less

maintained. In all other districts of the Presidency exotic cottons have failed to take any prominent established place amongst the cultivated varieties. Even in Dhárwár the cultivation of the exotic is declining and that of *kumpta* extending. Dhárwár and Belgaum enjoy a more or less unique climate, and it is this circumstance more than any other which has enabled there the successful acclimatization of New Orleans cotton. As regards other cotton districts with ordinary climates, it has, I think been demonstrated with certainty many years ago that exotic varieties are unsuited to the ordinary agricultural conditions. Further than this, it may be confidently stated that even an indigenous variety found suitable in one district might prove unsuitable for another. The only hope of improvement lies in taking the varieties in general cultivation as we find them, and making efforts to improve them by selection of seed continued from year to year.

In Dhárwár the American variety begins to flower in December, generally a fortnight before the local variety. The crop is picked between February and March.

In ordinary season there is not much difference in outturn between varieties ; 100 lbs. lint or about 300 lbs. seed cotton may be taken as average outturn.

Khándesh Cotton.

The variety of cotton in general cultivation is known as *varádi* or *nimári*. This is a short stapled cotton with coarse fibre. The lint, however, is very white in colour, and is for this reason suitable for mixing with other cottons of inferior colour. The plant is hardy, and in ordinary seasons with ordinary cultivation yields a fair outturn. Efforts to improve the cotton of Khándesh were begun in 1831, and were continued with great perseverance for many years. At one time the *varádi* was, to a large extent, supplanted by foreign varieties yielding long stapled cotton of fine quality. The history of cotton improvement in Khándesh is well told in the Gazetteer of the District. The results, if epitomized, may be stated as follows: that exotics were found difficult to acclimatize, that when acclimatized they degenerated, they yielded well when acclimatized in favourable seasons and with careful cultivation on particular kinds of soils, but in unfavourable seasons they were either seriously injured or irretrievably damaged. On the other hand, it may be claimed for the local variety that its cultivation is attended with less risk, that it suits the various descriptions of soils of the district, and is not seriously affected by too much or too little rain or other ordinary unfavourable conditions of climate. The natural consequence is that *varádi* is now grown over nearly the whole Khándesh cotton area, and its cultivation will continue until the

Efforts to improve Khándesh cotton failed for reasons given.

Khándesh cultivator finds a superior variety which can be grown without risk, and which he is also convinced can be grown with greater profit.

Khándesh cultivation of *varádi* cotton.

The crop is grown on black as well as on light soil, and generally occupies the same field once in three years. In the other years *jowári*, wheat, gram or linseed may be grown on black soil, and *jowár*, *bájri*, sesamum, &c., on the light. The light soil crop yields best in years of heavy rainfall. The black soil crop is best with moderate rainfall. Manure is generally given to the crop taken before cotton. A good cultivator prepares the land for cotton carefully. The field gets similar preparatory tillage to that described for other districts. The seed should, if possible, be sown in June. A two coultered drill is used. The rows are about 18" apart. The seed rate is 10 to 12 lbs. per acre. The seed is prepared for sowing as in other districts, but is not sown through the seed bowl and tubes of the drill itself, but through two separate tubes fastened by ropes one behind each coulter and each guided by a woman along the track or furrow made by the coulter. The bullocks are driven by a man. The women follow about 1½ yards behind the drill, and pour the seed through the bamboo tubes. The crop is hand weeded once and bullock hoed twice or oftener as required, the first time when the seedlings are 4 inches high. Cotton picking begins in October, and generally is complete in December. Three pickings at least are necessary. A good ordinary crop will yield 350 lbs. seed cotton per acre.

Cost of Cultivation, Surat District.

	Per Acre. Rs.	a.	p.
April—Twice harrowed in hot weather	0	14	0
Collecting and burning stubble of previous crop ...	0	4	0
May—Manuring—12 loads manure	6	0	0
June—Twice ploughing with light plough...	2	2	0
Digging corners and head lands	0	3	0
Twice harrowing	0	8	0
Sowings by drill and covering seed	0	9	0
Cost of seed 15 lbs.	0	4	0
Bullock hoeing	0	4	0
July-Aug.—Hand weeding and thinning out plants	1	10	0
Bullock hoeing second time	0	3	0
Sept.-Oct.—Ploughing between rows	0	8	0
Picking cotton crop 440 lbs. seed cotton	2	8	0
	15	13	0
Add—Assessment	6	0	0
Rs.	21	13	0

BOMBAY HEMP—*Crotalaria juncia*—Linn.

Natural order—*Leguminosæ.*

Sub-order—*Papilionaceæ.*

Tribe—*Genisteæ.*

Gujaráti, *San*; Maráthi, *Tág*, *San*; Kanarese, *Sanbu.*

Habitat.

Some authorities believe that the plant is found in a wild state throughout India. Others believe that the so called wild plants are escapes from cultivation. The origin of the plant is doubtful. It is everywhere cultivated in the plains in India.

General character of the plant.

San is grown for two particular purposes in Bombay—(1) as a green manure crop, (2) as a fibre plant. In each case the seed is thickly sown, and the plants grow unnaturally tall with very few branches except near the top. A good crop for fibre grows to a height of 6 to 8 feet. The yellow flowers grow in racemes. The pods are oblong, full bodied, and contain numerous kidney shaped, slate coloured seeds.

Distribution.

The total Bombay area is less than 30,000 acres annually. The crop is sparingly grown in all districts, the most important centres of cultivation being Ahmedabad, Panch Maháls, Surat, Khándesh, Násik, Sátára, Belgaum, Thána and Ratnágiri. In these districts the annual areas range from 2,000 to 4,000 acres.

Season.

San is usually sown during the rains. In the Thána District it is grown near the coast as a *rabi* crop in moist fields after early rice and chiefly on account of the value of the fibre to fishermen for their nets.

Soils.

The crop grows best in moderately retentive deep soils, such as are suitable for irrigated crops. As a green manure crop it is grown on all descriptions of *garden* land, also in rice beds.

Rotations and mixtures.

San as a green manure crop may be grown subordinate to *surans* and some other garden crops, and uprooted, broken up by hand, and put on the surface of the soil when 2 to 2½ months old. Usually, however, it is grown alone, and ploughed in as a green manure as a preparation for rice, sugarcane, and other irrigated crops. As a fibre crop it is always grown alone. It is rotated in no definite way with other crops, being grown mostly as a catch crop when favourable opportunities occur.

The special advantages of *san* as a green manure crop.

The seed is sown thickly; the seedlings on suitable soil and under favourable conditions grow very vigourously. A thick mass of vegetation is soon produced. This smothers all weeds. The crop should be ploughed in when 2½ months old. The tissues are then soft and cellular, and a large amount of organic matter which quickly decays is added to the soil. *San*, like other leguminose crops, increases the store of combined nitrogen in the soil. It is probably the best green manure crop known.

Cultivation.

A luxuriant crop cannot be grown without careful tillage. Quick growth is necessary for successful results, whether the crop is grown for fibre or green manure. A smooth friable seed bed is, therefore, required, and this can only be obtained by ploughing and repeated harrowings. The seed is generally drilled in July ; in the Deccan with a four-coultered drill, first lengthwise, then across the field. The drill coulters are 12″ to 14″ apart, and the double drilling secures even distribution of the necessary heavy seed rate (about 70 lbs. per acre). If the seed germinates properly, no further culture is required until the crop is ploughed in as green manure or reaped for fibre. In the former case the plants are allowed to grow to a height of 2½ to 3½ feet. A long fairly heavy log of wood should now be drawn horizontally over the crop to level it. A country plough should then be worked. Women following the plough should place the levelled stalks by hand as far as possible in the furrow, so that the soil moved by the plough in making the next furrow covers them. The field should now be left undisturbed until the *san* has decayed to a considerable extent ; then the tillage necessary for the succeeding crop may be started.

The fibre crop.

The preliminary tillage, seed rate and method of sowing is the same as for the green manure crop. If the seedlings come up somewhat crowded, they should be sparingly thinned out to leave a clear space of at least 2″ between plants in the rows. The crop should be allowed to grow almost or quite to maturity. This takes about 4½ months. The fibres or fibro-vascular system develope fully as the crop matures. The finest, strongest and best fibre may possibly be got from plants which are not dead ripe, but very good fibre as well as seed are got from a ripe crop. The stalks are harvested by uprooting and are left exposed to the sun for a few days, and then are tied into neat bundles, easily handled. Each bundle contains about 100 stalks. The bundles should be stooked up and thoroughly dried for two or three weeks. The leaves and seed vessels are easily removed by light beating.

Process of extracting the fibre.

The threshed bundles are tied, about fifty together, in a big bundle. These bundles weighted by stones are steeped horizontally in water. The fibre is extracted easiest in the hot weather. The heat of the atmosphere and of the water hastens fermentation, so that the fibre readily separates. *San* should be steeped for five days. The bark with fibre is then readily separated by hand from the root end upwards. About 2 lbs. of these strips are beaten with a stick on a stone for about two minutes. The strips are then threshed in the water of a stream or tank until long clean fibre is seen separate. The half cleaned fibre is again beaten with a stick on a stone and again threshed in the water,

The whole beating and threshing process takes about fifteen minutes. The hank of fibre is now made into a twisted bundle, and these twisted bundles are kept in a heap for two or three days and then opened out, and hung over a rope in the sun for three days to dry and bleach. The fibre is now made into a three ply plat like a Chinaman's pig tail and is ready for market.

Value and economic uses.

It is worth, when clean, long and good, about 5 lbs. per rupee, and is sometimes dearer. It is used for twine, bags, ropes, &c.

Outturn.

The following outturn results were obtained in 1898 from a moderately good crop at the Poona Government Farm:—

Dry Ripe Stalks, Leaves and Seed removed. Per Acre.	Fibre Per Acre	Percentage, Fibre to Dry Stalk.
Lbs.	Lbs.	
6,280	520	8·2

The value of the fibre crop in rotation.

The fibre crop, like the green manure crop, is excellent for rotation. The roots extend well into the subsoil, and this great range enables the plant to collect plant food through a large bulk of soil. The leaves fall as the crop ripens, and litter the surface soil with a top dressing which serves to manure the succeeding crop. A large stock of assimilated nitrogen is left by the roots in the soil.

DECCAN HEMP OR AMBÁDI—*Hibiscus cannabinus*—Linn.

Natural order—*Malvaceæ*.

Tribe—*Hibisceæ*.

Vern., *Sheria*, Gujaráti; *Ambádi*, Maráthi; *Punli*, Kanarese.

Habitat.

Watt says: "A small herbaceous shrub, apparently wild East of the Northern Ghâts." It is largely cultivated for its fibre throughout India, but more extensively in the Central Provinces, Madras and Bombay than in Northern India.

General character of the plant.

Ambádi is an annual. It is grown in Bombay subordinate to other crops, and the natural tendency of the plant to branch freely is checked to some extent. The plant grows under favourable conditions to a height of 3½ to 4½ feet. The leaves are alternate with long petioles, the lower stem leaves being entire or serrated, ovate cordate, whilst the upper ones are deeply lobed with three to five divisions. The lobes are narrow, sharp pointed, and serrated. The flowers are large, bright yellow, with purple red centres. The fruit is a capsule, rounded, enclosed in calyx. The stems, petioles of leaves and the fruit are prickly, and the plant is not easy to handle. The seeds are of three cornered peculiar shape, very dark grey, nearly black, with faint small numerous spots of lighter colour.

Distribution. *Ambádi* is cultivated all over India in the plains. The Bombay statistical returns show an area of about 90,000 acres annually. It is an important crop in all districts, but is most important in the Deccan and Karnátak. The crop is grown as a mere sprinkling among other crops, and the actual area in which the crop is grown is very large indeed.

Mixtures, soils, season. There is a sprinkling of *ambádi* in almost every *bájri* field in the Deccan and in Northern Gujarát. It is also grown subordinate to *jowár*, not so much in pure black soil as in soils of lighter description. It grows best on the alluvial soils of Northern Gujarát, but does very well in medium black soils in the Deccan. It is always a rain crop, and is rarely grown alone.

Cultivation. The tillage is the same as that of the crop with which it is associated, and the cultivation has, therefore, been already described under the head *bájri*. The plants ripen in October-November, and should be uprooted, then dried in the sun for a few days and tied into small bundles containing 35 to 40 stalks.

The leaves and capsules are separated by beating the bundles smartly on a log or board after they are thoroughly dry. The seed is separated from the capsules by beating with a stick and cleaned by winnowing in the usual way.

Extracting the fibre. The small dry bundles of *ambádi* are tied, like *san*, into large bundles. These in the hot weather are steeped in water and weighted down with stones for ten days. *Ambádi* requires to be steeped longer than *san*. When removed, the bark and fibre should readily peel off from the root upwards, and is cleaned and prepared for market in precisely the same way as already described for *san*.

If the fibre is separated in the cold weather, longer steeping is required, and entire fibre from the root to the top of the stems is not obtained. The strips or ribbons break off irregularly about the middle of the stems.

Value and economic uses of the fibre. The fibre is worth about 8 lbs. per rupee. It is largely used by cultivators for their home requirements, such as well and cart ropes, plough draft ropes, halters for cattle, &c.

Outturn. In 1898 a crop grown alone at the Poona Farm in good mixed black soil in a favourable season gave the following outturn results :—

Dry stalks stripped of leaves and fruit. Per Acre. Lbs.	Fibre. Per Acre. Lbs.	Percentage fibre to clean dry stalks.
5,733	973	17

LUCERNE OR *ALFALFA*—*Medicago sativa*—Linn.

There is no vernacular name, except corruptions of the English name or to signify that the plant is English or foreign. De Candollo says that lucerne has been found wild with every appearance of an indigenous plant in several provinces of Anátoba in the South of the Caucasus, in several parts of Persia, in Afghanistán, in Beluchistán and in Káshmir. He thinks it curious that lucerne has no Sanskrit name. Habitat.

Lucerne has been grown in India for at least 100 years, but its cultivation has certainly not been ancient. The chief cultivation is believed to have originated near military cantonments and rearing and remount depôts. The area is fairly extensive in parts of the Bombay Presidency, especially near Poona and Ahmednagar. General distribution in India and Bombay.

Lucerne is of the clover genus. It has trifoliolate leaves, and papilionaceous flowers of a purple colour. The fruit is a legume or pod, twisted in a peculiar spiral manner, and contains six or eight seeds which are small, kidney shaped, and yellow to brown in colour. The plant is a perennial, and under favourable conditions thrives for four years or longer. When well established, many shoots spring from one root. Lucerne, like many forage plants of the same natural order, sends its long tap roots deep into favourable subsoils, particularly those of a calcarious character. It grows to the height of about 2½ feet, and on suitable, well manured soil will produce, after being cut, a full crop in six weeks. It grows most vigourously during the rains, much less so in the hot weather. Habit of growth.

It is recognized as one of the most valuable of fodder plants, resisting drought in an extraordinary way in those countries where it is grown without artificial watering. It shows its best results under irrigation on deep friable loam soils, with a limestone subsoil, and with a liberal application of suitable manure. It does not do well on black or heavy soil, because such land is unsuitable for irrigation. It does fairly well on light sandy loam. Resists drought in temperate countries, but gives its best results under irrigation in hot countries. Soil suitable or unsuitable.

Lucerne generally commands a high price (about 100 lbs. per rupee), and generally forms part of the daily ration of horses in hard condition. To milk cattle it can only be sparingly fed. 10 lbs.—the daily allowance for a horse—is also the maximum quantity that can be fed to a cow. Its tendency to cause tympanites is the danger to be guarded against in feeding it to ruminants. More suitable as fodder for horses than for cattle.

There are at least two varieties of lucerne cultivated in India. The Persian or Arabian variety is that ordinarily grown. The Kandáhár lucerne is sparingly grown, but is not a variety to be recommended. The stems have a trailing habit of growth, the leaves are small, and Varieties.

each time the crop is irrigated, the lower branches are submerged, and thereby the leaves get yellow and fall off. The Arabian lucerne is much more upright and vigourous in its habit of growth.

Price of lucerne seed. Method of determining as to soundness and vitality.

Lucerne seed is dear. The price ranges from As. 14 to Re. 1-8 per pound. Its soundness can, to a certain extent, be judged off by sight. If it is plump and glossy, and the seeds are mostly rich brown in colour, it is probably good. But it is safest to test the germinating power of the seed before sowing. This can be conveniently done by noting the percentage of seeds which strike when kept in moist flannel in a warm place for two or three days.

The best time for sowing.

The best time of sowing in the Poona District is either early in the rains or between October and December. If sown at any other season, it is apt to be attacked by aphides (green fly) or eaten by caterpillars whilst the seedlings are young; or, if sown in the hot season, the young tender seedlings are scorched by hot winds. The best time for sowing in the North of India (where the crop does exceptionally well) is from the middle of October to the middle of November.

Native methods of sowing and of irrigating.

The usual native method of sowing is to broadcast the seed on a clean, well prepared bed about 10 feet square. 16 to 20 lbs. of seed per acre is required. The seed is lightly covered with soil by means of a wooden rake. A through water gutter generally runs between each double line of beds, but the arrangement of the water channels is regulated by the evenness or otherwise of the field surface. Water is given every ten days in the cold weather or during breaks in the monsoon, every six to eight days in the hot season according to the character of the soil. The water is directed from the water channels into each bed in turn. Lucerne planted in this manner will yield heavy cuts for two or three years. Meantime, the field gets foul by deep rooted grasses and other weeds which the cultivator is powerless to suppress, and on this account the lucerne fails when it ought to be in full vigour. In this respect the country method resembles lucerne cultivation in England, where it is grown in rows about 12 inches apart. The crop gets smothered after two or three years with twitch grass and other weeds in spite of periodic horse hoeing.

Disadvantages of native method of cultivation.

Initial cost of cultivation heavy.

It is important that the crop when once established should last, because the initial cost of laying it down and subsequent outlay in manures are alike heavy.

A good method of cultivation.

The following is a better method of growing lucerne than the country plan. The field should be well ploughed and brought into a thoroughly friable, smooth, clean condition during the rains. In September a liberal dressing of thirty loads per acre or more of thoroughly decayed farm yard manure should be given. Half rotten manure

Manure.

does not answer well, because it keeps the soil open. It does not supply the needs of the young seedlings at once, and white ants are attracted to the field. The manure should be evenly spread, and by subsequent ploughing and harrowing mixed thoroughly with the soil. Ridges are then formed. The seed is sown on the ridges which can be made 22 to 28 inches apart by an ordinary native plough. In practice it is found necessary to fashion the ridges afterwards into neat proportions with the hand hoe. The slope of the surface of a field will indicate the direction in which the ridges should be drawn. Irrigation water must slowly flow along each furrow. If the inclination of a furrow is too great, soil and manure are swept to the lower level of the field by the water getting too much velocity. The crop is, moreover, unequally watered, that on the lower portions of the field getting too much water, while that on the higher portion gets too little.

Preparation of the soil and ridging.

Proper arrangement of furrows for irrigation.

A rather deep groove is made along the top of each ridge with a light hoe. The seed is best sown by hand. It should be carefully sown and carefully covered by not more than 1½ inches of soil. The whole operation rounds and flattens the ridges, and permits the seedlings to spring up in lines, covering a width of 3 or 4 inches. Crowding of the seedlings in dense rows is thus avoided. The importance of fine tilth is obvious, because the seed is small, and the seedlings very delicate until they take a firm hold of the soil. Frequent waterings are required during the first fortnight. The seedlings would probably wither, if exposed on the top of a ridge to a hot wind unless sufficient moisture is within reach. This method of sowing effects a saving of seed. 10 lbs. per acre is ample.

Sowing and seed rate.

One object of sowing lucerne on ridges is to raise the stems of the plants out of contact with irrigation water. Under natural conditions the plant requires very little surface moisture. Its great root development enables it to collect enough in the subsoil, and therefore, when water floods the crop as well as the soil, as in the ordinary bed system, unhealthy conditions are induced, particularly in low lying places. If the plants become submerged in water, and are afterwards exposed to the sun, they turn yellow and unthrifty. On medium soil, lucerne planted in the above manner requires water every eighth day in the cold season, every sixth day in the hot weather, and oftener if the soil is light. Water should be given also during breaks in the monsoon.

The advantages of the "ridge and furrow" system of cultivation.

The principal object aimed at in adopting the ridge and furrow system is to keep the field clean. The furrows can be weeded each time the crop is cut by using an ordinary bullock hoe or scuffler. I have found the American Planet Jr. hoe—which with extra parts costs Rs. 33 in Bombay—the best possible implement for the purpose. It

Weeding by means of Planet Jr. hoe.

is easily worked by a pair of bullocks, and can be drawn by a rope or chain attached to an ordinary neck yoke. If fitted with grubber tires in front, and an earthing up double mould board behind, it grubs up the weeds, and earths up the ridges at one operation. It can be adjusted to any ordinary width of furrow over 18 inches. If manure is applied at every second or third cutting as it ought to be, it can by means of this hoe be incorporated with the soil and placed directly in contact with the roots of the crop. Moreover, the furrows are left clean, so that water can flow properly. Lucerne requires liberal top-dressings of manure at short intervals. There is nothing better than well rotted farm yard manure. At least five tons should be applied every third time the crop is cut. (It should be cut as soon as it comes in flower.) If farm yard manure is not available, castor cake, 3 to 4 cwts. per acre, is a good substitute. With the above treatment a crop will be well established in six months, and should last for years, yielding at least ten cuts per annum.

Top dressing and manures suitable for top dressing.

Lucerne does better in the North of India than it does in the Deccan. In the Poona District the crop is liable to damage from disease and many mishaps. Thriving plantations have been attacked with aphides, caterpillars, and a fungoid disease. The insects swarm in such numbers that any ordinary insecticide application has little or no beneficial effect. Dusting the affected plants with ashes and lime does some good, but the best plan is to cut the whole crop, carry it to a distance, and burn it. A belief is held by native cultivators that a border of carrots round a patch of lucerne will keep away insects while the lucerne seedlings are young and until the plants are well established. I have seen many fields almost totally destroyed by green fly in the hot season recover somewhat in the rains. Heavy continuous rain will completely destroy the pest.

Diseases and methods of prevention.

In the North lucerne is often damaged by frost. It is everywhere liable to be attacked by dodder—a plant parasite which, on account of its bright yellow colour, is easily discernible. The host plants should be grubbed out at once, and burnt root and branch. The pest is also found in the Poona District.

Damaged by frost and by dodder.

The fungoid disease which is so destructive in the Poona District attacks the roots. It is most destructive in wet seasons, and is not amenable to treatment with copper sulphate solution as most fungoid diseases are. It is noteworthy that a piece of lucerne on the Poona Farm, which had become patchy through this disease, was filled up by planting guinea grass. The mixed crop corresponding to the "rye grass and clover" of England did exceptionally well for two years, the lucerne keeping quite healthy until finally grubbed up.

The Poona fungoid disease and a possible remedy.

It may be that the losses due to disease may be avoided by growing lucerne mixed with guinea grass. Lucerne, if it remains healthy, is one of the most paying crops which can be grown. But in the Poona District there is a considerable risk of considerable loss by its cultivation.

The best results on the Poona Farm during 1892-93 and 1893-94 were as under:— Outturn results, Poona Government Farm.

	Outturn per Acre.	Value per Rupee.	Cost of Cultivation per Acre.	Value of Produce per Acre.	Remarks.
	Lbs.	Lbs.	Rs. a. p.	Rs. a. p.	
1892-93	83,793	120	330 6 0	698 4 3	Ridge and furrow crop.
1893-94	31,816	120	85 3 8	265 2 0	Do.

Lucerne does not make good hay. Unless it is dried and handled very carefully, the leaves get so brittle that the greater proportion of them fall off, and are lost before the dry fodder can be stacked and little but dry stalks remain. Lucerne does not make good hay.

If lucerne is saved for seed, this should be done about the middle of the cold weather. Water should be sparingly given and withheld as the seed ripens. The object is to prevent a too succulent growth of stems and leaves, to encourage the formation of flowers and seed-vessels, and to produce plump seed which has slowly matured. Saving lucerne seed.

GUINEA GRASS, *Panicum jumentorum*—Pers.

Guinea grass is a native of tropical Africa, and is now cultivated in many hot countries. Watt says that "guinea grass appears to have been first cultivated in the West Indies, having been grown in Jamaica since the middle of the eighteenth century. It was recommended for cultivation in India as early as 1793 by Mr. W. Fitzmaurice." Habitat and general distribution.

This perennial grass grows in tufts or hussocks, many stems springing from one root. The roots are fibrous, and form a network in the soil near the surface. In countries of moderately temperate climate, such as that of the plains of Northern India, the grass remains more or less dormant in the cold weather, but flushes up with warmth and moisture afterwards. In the hotter parts of India the grass remains green throughout the year under irrigation. It may even exist without irrigation in the fair season. Such plants as survive spring up into vigorous growth when the rains come. In the monsoon and sometimes at other seasons the grass flowers and produces seeds General character of the plant.

freely in India. When in full flower, the stalks are 5 to 8 feet high, and the graceful branching panicles give the crop a very handsome appearance. During the greater part of the year leaves are produced rather than flower stalks. The best results are obtained with copious irrigation throughout the year and with heavy applications of manure. In the warmer parts of India guinea grass grows best in the monsoon and the early part of the cold weather. It has no dead season, but gives a decidedly poorer outturn in the fair season than in the monsoon.

Distribution in Bombay.

The area is not separately returned. It has extended within recent years, and is considerable in the vicinity of military cantonments, at the Remount and Rearing Depôt, Ahmednagar, near Karáchi, and in other parts of Sind, and in Native States, and particularly in Gujarát and Káthiáwár. The cultivation has chiefly extended from Government Farms.

Propagation.

Guinea grass may either be propagated from the true seed or by sub-division of the root stock. The latter is the preferable plan. The hussocks become overgrown in a two or three year old crop, and the plantation is improved if each root stock is diminished in size all round. This can be done by means of a spade or native pick; the portions removed will furnish sets for planting a new area.

Soils.

Guinea grass, like lucerne, does best on deep medium loam which can be irrigated to advantage. It also does well in light deep sandy soil, such as the *goráḍu* soils of Kaira and Ahmedabad, or the alluvial sands of Sind.

Cultivation.

The soil should be friable to a considerable depth, and such tilth can only be obtained by repeated ploughings and harrowings. Thirty cart loads or more per acre of thoroughly decayed farm yard manure should be given and freely mixed during preparatory tillage with the soil. Each set should consist of four to eight stalks, each well rooted. Each set should be carefully planted 20 to 24 inches apart in each direction. The rows should be accurately straight both lengthwise and across the field. The sets should, in the first instance, be planted on the flat, and, if possible, during the rains. At any other season, in order to induce quick growth and non-failure of sets, the field should be swamped with irrigation water immediately after planting. If there is a fair slope in any direction, the irrigation water can easily be led over the whole field. The sets can be planted during the monsoon advantageously on moderately light land, when light rain is falling or immediately before rain, and on heavier soil soon after rain. When the crop has become established, the rows should be ridged up in the

same manner as for lucerne and in the direction of the least slope of the field, so that the irrigation water, when applied, may run slowly along the furrows. Subsequently, guinea grass can hardly get too much water or manure. The water must not, however, stagnate. Ridging and watering.

The hussocks get overgrown in about two years, and it pays to grub up a plantation which has been established about three years. The ground need not necessarily be changed. New sets should, in the first instance, be chopped off from the old hussocks, and planted in the furrows at the required distance apart, and, when established, the old plantation can be grubbed up. If this plan is adopted, the new plantation is almost in full vigour before the old plantation need be removed. Plantation should be renewed in three years

It is important that guinea grass should be kept clean, and if the sets are planted straight, both lengthwise and across the field, this can easily be managed. A country bullock hoe or country plough can be worked in any direction, and weeds which are not removed by these implements should be removed by the weeding hook (*khurpa*). Guinea grass requires to be watered and manured as regularly as lucerne, but the former probably requires more manure than the latter to produce the best results. There is no better manure than well rotted farm yard manure, and it should be applied in dressings of at least five tons per acre every fourth time the crop is cut. Weeding. Top dressing.

If guinea grass is propagated by seed, the seed should be thinly broadcasted in a well prepared seed bed. When the seedlings are well grown and have each produced three or four shoots, they should be transplanted into rows in the manner already described for sets. Propagation from true seed.

Guinea grass is almost exempt from disease of any sort. Smut sometimes appears; but as it attacks the seed, it does no great harm, because the crop is generally, and should be, cut as fodder before the flowers and seeds are produced. Diseases.

When the flower stalks appear, the herbage is coarse and fibrous, and not nearly so suitable as food for horses and cattle as at an earlier stage. In cutting a crop care should be taken that the hussocks are reaped as close to the crown of the roots as possible, because subsequently the stubble which is otherwise left, and which sometimes stands 9 inches to a foot high, prevents the green succulent shoots being cut so near to root stock as is advisable, and, therefore, considerable loss occurs. Fodder coarse when the flower stalks appear. Reaping.

The crop provides an exceptionally fine fodder for all descriptions of farm animals, and can be fed without any waste to highly fed animals. Perhaps, its most valuable characteristic is that it grows well under the shade of trees where no other fodder crop or grass will thrive well. It does well in damp situations, if water does not positively stagnate there. Moreover, it has the decided advantage of growing well con- The advantages of the crop.

tinuously on the same land without rotation. It is believed that guinea grass is as suitable a food for horses in hard work as lucerne is, and for young horse stock and dairy cattle it cannot be surpassed.

Suitable green fodder for horses and cattle.

At the Remount Farm, Ahmednagar, the young horse stock are regularly fed with it. The daily ration increases with age, 25 lbs. chaffed with dry food being the maximum daily allowance. For dairy cattle it can be fed up to 40 lbs. per day with every advantage.

Can be ensiled or made into hay.

It can either be ensiled or made into good hay. As regards conversion into hay, it has this advantage over ordinary grass that it grows during the fair season, and is then in the primest condition for hay-making, and can be made into hay without the slightest risk of being damaged by unfavourable weather. On the Saidápet Farm guinea grass was found to be excellent grazing for work cattle, also for ewes and lambs, but it appears necessary that it should not be grazed too closely.

Outturn.

The Poona and Surat Farm crops have given outturns ranging between 20,000 and 35,000 lbs. per acre according to season. The crops are cut about eight times in a year.

TOBACCO.

Natural order—*Solanaceæ*.

Genus—*Nicotiana*.

Gujaráti, *Tamákhu*; Maráthi, *Tambákhu*; Kanarese, *Hogesoppu*.

Habitat.

The genus *nicotiana* which produces the various forms of commercial tobacco contains about fifty species, and all, with two Australian exceptions, are natives of America. Five or six species are cultivated, but of these only two are found in India, *viz.*, *N. tabaccum*, Linn., and *N. rustica*, Linn. The former is the common tobacco of India, and, as its name indicates, is the chief of tobacco yielding plants. It is believed to be a native of Central or South America. It is an annual plant, standing, when well grown, 4 to 5 feet in height, with large, oblong and ovate pointed leaves. The upper leaves are sessile. The lower leaves, sometimes with or sometimes without stalks, are much larger than the upper leaves. Flowers appear as terminal panicles, and vary in colour from white to pink. The fruit (a capsule) is egg shaped, and contains numerous, very small, pale brown seeds of irregular shape.

Nicotiana tabaccum.

Nicotiana rustica.

N. rustica is cultivated in parts of Punjáb, Bengal, and Assám. It is a smaller plant than *N. tabaccum*, and differs from it in several respects, the most noticeable being that the leaves are stalked, the capsules are globular, and contain oblong seeds which are larger than those of *N. tabaccum*.

Introduction into India.

Tobacco, like its allies the potato and chillies (*capsicum*), was introduced from the New World to the Old. It reached the Malabár Coast *via* Spain and Portugal in 1604; some authorities say at

slightly earlier period. Since that time it has spread over the whole of India, and now is cultivated over an area of about 2,000,000 acres.

Distribution in the Presidency

Belgaum and Kaira are the two chief centres of cultivation. Elsewhere the crop is only important in Satára, Khándesh, Ahmednagar, Ahmedabad, and Broach.

Soils suitable.

In Kaira and Ahmedabad, tobacco is grown in alluvial soil of great depth, which is of fine consistence, and varies in character from a sandy loam to a moderately stiff or clay loam. The Broach tobacco is grown chiefly in the bed of the Nerbada on *bhátha* land which is alluvium of sandy loam consistence, brought down by annual floods and found in the beds or shelving banks of rivers (chiefly the Nerbada). In Satára, Ahmednagar, and Khándesh tobacco is grown to some extent as a riverside crop, but also to a considerable extent on the greyish coloured soils of old village sites or as a dry crop on purely black soil. In the latter case the fields are generally close to the villages. In Belgaum the crop is extensively grown in Chikodi, to a fair extent in Athni, but sparingly in other tálukas. The crop is grown in black soil fields near villages and on riverside fields. The best tobacco is grown on the deep alluvial lands near the Krishna.

Cultivation Gujarát.

In the Kaira District and in adjoining Baroda Territory the cultivation of tobacco is extensive. Throughout this tract wells with salt water are very common. The water from such wells is extensively used for irrigating tobacco, and in some instances with remarkable manurial effect. Particular wells in the neighbourhood of Nadiád (Kaira District) and Petlád (Baroda Territory) contain water which is specially valuable for irrigating tobacco, and the owners derive a large income by selling to occupants of tobacco fields the right to draw water by *mot* (*kos*) from their wells. There is no doubt that the water of certain wells has high manurial value. At Nadiád in certain fields tobacco has been growing continuously for many years without any manure except that derived from the water of salt wells. Dr. Leather's professional enquiry regarding the composition of these well waters shows that there are remarkable differences between the waters which are recognised as sweet and such as are called salt by ordinary cultivators. Wells with sweet and wells with salt water are often found in the *Charotar* villages within a stone's-throw distance of each other. The salt water in some wells is considered particularly effective for tobacco, that in others less effective. Dr. Leather concludes that the cultivator's opinion of the value of these well waters is perfectly sound. He found large amounts of nitrates in the well waters held in highest repute by the cultivators. The water from such wells is mixed in definite proportion with water from sweet wells as it is being used for irrigation.

Value of the salt wells of Gujarát for tobacco.

Dr. Leather calculates that the mixed water gives to a tobacco crop during the season about 500 lbs. nitrates of potash per acre. The analyses show, however, that the percentage of potash was very considerable in some waters and wholly absent in others. In some cases the nitric acid reached the crops therefore in other combinations. But as the tobacco soils are generally rich in potash, a deficiency of this ingredient in the well water could not be felt by the crop. The reader is referred to Agricultural Ledger No. 14 of 1895 for full details of Dr. Leather's enquiry.

Soils suitable for different sorts of tobacco.

A free working, well drained soil is best for tobacco. In Gujarát on such land with sweet water for irrigation mild flavoured tobacco of good quality can be grown. But the native cultivator likes strong tobacco and a heavy crop of large coarse leaves. A crop yielding tobacco of this class grows best on medium clay loams irrigated with sweet water or with salt and sweet water combined. The *Charotar* villages of Kaira and Baroda Territory are the principal tobacco growing centres of Gujarát, and the tobacco growing soils of these villages are chiefly light coloured loams or sandy loams. Dr. Leather found that representative tobacco soils of the *Charotar* villages contained distinctly large percentages of potash, full average quantities of phosphoric acid, but the proportions of nitrogen in all are very small.

Rotation.

Tobacco is rarely rotated in Gujarát with other crops. It is claimed that the longer the soil is under the crop, the better is the produce. The soils of the *Charotar* are exceptional in being of immense depth with great natural fertility. Continuous tobacco would not be profitable on less fertile soils. Tobacco requires a full supply of nitrogen, potash, and lime, but makes no great demand on the soil for phosphates; therefore, by its continuous growth the resources of an average soil are not fully made use of. There are other objections, the principal one is that continuous growing or frequent growing encourages parasites, such as the broom rape which in Gujarát frequently does great damage in tobacco fields. There is little doubt that this plant parasite and other pests, particularly insects, would do much more harm than they do, were it not that the climate of Gujarát favours, to a particular extent, the rapid decomposition of the roots, stems and other residues of the crop which are not removed from the field. Occasionally on fields badly infested with broom rape the cultivator grows an irrigated crop of *sundhia jowár* in the hot weather. Tobacco follows in its ordinary season. The broom rape does less harm than usual, but the tobacco does not yield an average outturn.

Seed beds.

These should be prepared on elevated ground and under tree shade. The site should be selected which is likely to be affected as little as possible by heavy showers of rain. Tobacco seedlings, when young, are

very delicate, and need all the protection from the sun and storm which can be arranged for. In such villages as grow a considerable area of tobacco a special piece of ground is usually set apart as a common nursery. An acre of transplantation requires a seed bed of 100 square feet at least. The seedlings before transplantation are liable to many mishaps, and some, when transplanted, fail to grow; therefore, it is well to have a sufficiently large nursery to meet such eventualities. The best plan is to have a succession of seedlings. The seed beds should be sown at intervals of a week. Seed beds 200 square feet in extent in the aggregate and sown at intervals will provide all the seedlings which will be required to plant an acre, and leave plenty to spare. The best cultivators have usually large seed beds, and sell surplus seedlings to their less skilful neighbours. Seed beds should be prepared with care. It is a good plan to *ráb* them by burning on the surface, before the rains set in, refuse, straw or hay, brush wood or cowdung. The *rábing* has greatest effect if the soil has been previously dug lightly with a light pick and the lumps broken into a comparatively fine tilth. The burning improves the mechanical condition, the ashes manure the soil, and the heat kills weeds and insects. A *rábed* seed bed should be manured with goat manure. One cart load is sufficient for a nursery for an acre of transplantation. The goat manure should be well mixed with the soil, and as fine a tilth as possible obtained by hand digging, &c. There is ample time to prepare the seed bed thoroughly, as the seed should not be sown until July. One ounce of fresh seed is sufficient to sow 100 square feet of seed bed. The seeds are very small, and should be mixed with a considerable proporition of fine ashes or fine sand before sowing. This secures even distribution. The seed when sown should be lightly covered with soil, and the surface pressed down. Heavy rain is disastrous, and continued dry weather is nearly as harmful. The seed beds may, therefore, need light watering by hand or protection from heavy rain. For the latter purpose, in some parts of India tatties of bamboo and straw, erected at some little height from the ground and removeable in fair weather, are used. This practice might, with advantage, be adopted in Gujarát. Weeds, as they appear, must be removed from the seed beds, and the seedlings may need thinning out. If they are too close together, they grow tall and weak, and are difficult to transplant successfully. Seedlings which are allowed sufficient room in the seed bed get their roots properly developed, and can be lifted when required for transplantation without damaging the roots materially. Caterpillars must be diligently looked for in the seed beds every morning and removed or destroyed, otherwise great damage will soon be done to the young plants.

Preparatory tillage in tobacco fields.

The stems and roots of the preceding tobacco crop should be grubbed up and burnt or otherwise disposed of as soon as possible after the leaves are harvested. Burning is the preferable method of disposal. If left in the ground, the crop residues retain a certain amount of vitality, and those of the crops which have been irrigated owing to the effect of soil moisture send forth shoots which grow to a certain extent. Even in the case of dry crops there is the same tendency. This growth has no material value. On the contrary, plants which are kept alive after harvest help to perpetuate broom rape or other diseases. In Gujarát, as in other districts of the Presidency, the stems and roots of tobacco are usually left undisturbed during the fair season, and this practice cannot too severely be condemned. It is, of course, easier to dig up the roots when the ground has been softened by anti-monsoon showers or by the first monsoon rainfall, and at this time the work is usually done. The field is ploughed as soon as possible after the monsoon has set in, and, as the cultivators believe in deep and frequent tillage for tobacco, the plough is frequently used between June and August. The *hal* of Gujaràt is a very light plough. The local work cattle are strong and active; therefore the preparatory tillage is not particularly expensive, even though eight or ten ploughings are frequently given. But the extent of this tillage would be fairly represented by four good ploughings given by the Deccan plough. As a matter of fact, two deep ploughings by a really effective indigenous plough and the subsequent use of the bladed harrow or scarifier (which is much the same pattern in all districts) would, at less cost, produce tilth as good and as suitable for transplantation of tobacco seedlings as that produced by the usual numerous ploughings given in Gujarát.

Manuring.

Manure is applied when the field has several times been ploughed. The soil of tobacco fields can in Gujarát usually be carted over without injury during breaks in the monsoon; therefore the practice need not be objected to. In heavy soil it would be preferable to apply manure in the fair season. Subsequent tillage would mix the manure thoroughly with the soil. Twenty-five to thirty cart loads per acre of ordinary, well rotted, farm yard manure is the usual application. A better practice than this is to fold sheep closely on fields intended for tobacco in the fair season. 150 sheep for a week on an acre would give a full average application of manure, and 200 sheep would give a liberal dressing. The mud removed from village tanks is considered good manure for tobacco fields if given in sufficient quantity. Forty cart loads or more per acre are usually given. The mud is dug out as the tanks dry in the fair season, and is then applied. If then spread on the field, the lumps crumble down owing

to the heat of the sun in the day and the cooling of the air at night, and can, therefore, be freely incorporated with the soil during the monsoon by ploughing. It is easy to understand that village tank mud, as the water dries up, may furnish a fairly concentrated manure if the village is large; because the tank receives the greater part of the village sullage, and buffaloes and other cattle stand or wallow in its waters for hours daily during the greater part of the year. The water and mud is fouled thereby, but, of course, improved manurially. It is believed that, though sheep dung and tank mud are good for tobacco, cowdung manure, if well rotted, is best, because it produces rich, fine, elastic leaves. There is in India no positive proof about this, only hearsay evidence, and such must be accepted for what it is worth.

The nitrogen and potash of manure probably the most valuable ingredients for tobacco.

The results of American experiments indicate that it is the nitrogen and potash of farm yard manure which are most beneficial to tobacco, and that the effect of phosphates may be discounted. In India the storage of farm yard manure is not usually exemplary. On the contrary, it is usually bad in practice, and the elements which are most useful for tobacco are those which would be lost in greatest extent by careless storage. The manurial value of salt water for tobacco has already been referred to, and, when such is available, the dressing of farm yard manure or other manure is usually light.

Transplantation.

The seedlings are ready for transplantation when they have four leaves and three or four inches high. The field should now be levelled with the *samár*—a plank, which is used as a roller. The surface is next lined and cross-lined with the *gisle* which has four teeth at regular distances apart. The lines thus made may vary from twenty to twenty-seven inches apart. The seedlings are carried from the seed beds in baskets, and only such as have straight stems and well developed roots are planted. A seedling is planted carefully at each angle made by the intersecting lines, so that the roots occupy a natural position. A cloudy afternoon is usually chosen for planting. The seedlings thus get a whole night before being exposed to the heat of the sun. Frequent watering is required after transplantation. The seedlings are covered lightly with twigs and leaves of the *neem* tree until they are thoroughly established. Those that are weakly or die are replaced. Much of the success of the crop depends upon careful transplantation. Light rain, in occasional showers, for a few days after transplantation is very beneficial.

Hoeing.

Hoeing should begin as soon as the plants have made a fair start. A bullock hoe with a blade wide enough to work between the rows is used. The blade must not be too long, otherwise the roots are disturbed or the young plants damaged. Weeds which cannot be

reached by the bullock hoe are removed by the weeding hook (*khurpa*). The plants should be planted in such exact lines that the bullock hoe can be worked either lengthwise or across the fields. Three double turns are usually given. In fact, hoeing should continue until the bullocks can no longer walk through the crop without doing injury.

Topping. When the flower bud begins to open, it ought to be removed and with it two to four of the youngest leaves. Ten to fourteen leaves should be left on each plant, the greater number in a rich soil. In some cases when small golden leaves are required for special purposes the plant is left untopped. When, however, it is topped, its whole strength is concentrated in perfecting the leaves left upon it.

Suckering. The removal of the flower buds when the plant is in full activity of growth is followed by the appearance of a number of side branches. These are known by tobacco growers as "suckers"—a significant term, but botanically they are not suckers at all. They should be regularly removed, because they use up the substance of the plant, thus deteriorating the value of the leaves. The removal of suckers involves much work. The field must be gone over many times in the season.

Irrigation. On *besar* soil (stiff clay loam) tobacco is raised as a dry crop. But, as a rule, tobacco in Gujarát is irrigated more or less according to the kind of tobacco to be manufactured. Tobacco meant for *jerdo* must get more irrigation than that intended for *kálio*. In an ordinary year irrigation begins early in November. Twenty days after the first watering a second is given, and afterwards others at intervals of twelve to sixteen days until the leaves are ripe, which is usually about the middle of February. In Gujarát the leaves are left on the plants either until they are decidedly yellow, or the colour has so far turned that the leaves would be considered overripe by an experienced European grower who thinks tobacco fit to cut when the leaf is brittle, crumbled on the surface, and covered with yellow spots.

Harvesting. Sometimes the entire tobacco plant is cut down; but the usual course is to strip off the leaves one by one from the stalk with a small bent sickle made for the purpose. The after treatment of the leaves depends upon the kind of tobacco to be manufactured.

Manufacture. Two kinds of manufactured tobacco are commonly made—*kálio* and *jerdo*—and a third (*chopadia*) is occasionally prepared.

Kálio tobacco. *Kálio*, used for smoking in the *hooka*, is made as follows:—The leaves, when stripped off the stems, are placed in threes, one above the other, on the ground. The threes are arranged in rows overlapping like slates on a roof. They are left thus exposed to the sun and dew for four days, and in the absence of dew are artificially damped. This half dried tobacco is built into heaps, and, when it has heated slightly,

it is tied into bundles (*padas*). The bundles are again put into heaps and subjected to gentle fermentation. The heaps are turned every second day for about a fortnight, at the end of which time the tobacco ought to be cured. The bundles when cured weigh at Nadiád, usually 1½ to 2 lbs. each. When ready for market, *kálio* is of a black brown colour. It is sold by the maund of 45 lbs. or by the 100 bundles. An average acre should yield from 1,000 to 1,400 lbs. The yield from a really good field may be 2,400 lbs. or more per acre.

Jerdo or yellow tobacco gets its name from *jerdo*, the soluble yellow colour which is washed out of safflower petals when preparing the red dye. There are two kinds of *jerdo*. That made from tobacco irrigated with sweet water is used for smoking, whilst that irrigated with brackish water is used for chewing or snuff. *Jerdo* is prepared as follows:—Two days before the tobacco is cut, the field is copiously watered. The leaves when stripped from the plants are laid on the moist soil, and lie exposed to the sun and dew for eight days. The moist earth prevents rapid drying, so the leaves take a bright, yellow colour. After they have acquired a proper colour, they are tied into *padas* and stored in a house. They are almost dry when stored. Therefore they do not ferment and blacken. They mature slowly, and *jerdo*, when ready for sale, should be of a brownish yellow colour. With irrigation by brackish water very large crops of inferior *jerdo* are obtained—3,000 lbs. or more per acre. With sweet water an average yield is the same as for *kálio*.

Chopadia tobacco is so called from the flattened "book-like" *padas* in which it is sold. It is only made from selected leaves which are dried, and coloured in the same way as *jerdo*, but more slowly, the process taking ten to twelve days. Leaves perfect in shape and ripeness are selected, and all of much the same size, and therefore only a proportion of any crop can be made into *chopadia*. *Chopadia* tobacco.

Tobacco suffers severely from parasites, both animal and vegetable. Various kinds of caterpillars do considerable damage to the seedlings and also to more mature plants. They can only be watched for, picked off and destroyed. Diseases.

Of vegetable parasites the best known is a species of orabanche (broom rape), called in the vernacular *vacumba* or *ágio*. Its white, fleshy stems, ½" in diameter, furnished with scaly leaves and surmounted by pale bluish white flowers, may often be found underneath tobacco plants. The broom rapes are common in Gujarát, and attack brinjals and tomatoes, as well as tobacco. They attach themselves to the roots of the host, and feed on the juices of the plant, and thereby very seriously diminish the yield. Although constantly removed by the cultivators,

a bad attack will destroy a quarter of the crop. The practice of continuous tobacco growing is so common and so favourable to *vacumba* that it is impossible to irradicate it. It more or less appears every year, and when the season proves favourable, as it seems to do at short intervals, the attack is bad, seriously increasing expenditure and reducing the outturn. Cultivators think that *vacumba* is an outgrowth from tobacco and that it has no separate existence. It is, therefore, left in undisturbed possession of the field when the leaves have been harvested. It flowers and seeds on the tobacco stalks. These stumps are left to dry in the field instead of being dug up and burnt as they ought to be.

Varieties of Tobacco, Bombay Presidency.

1. *Sumátrá.*—Plant tall, internodes of leaves being fairly far apart. Leaf has characteristic open habit of growth, with the upper surface slightly granulated and shining. It is narrow for a considerable distance near base, then widens gradually, and may best be described as spindle shaped. Midrib prominent, but not very coarse. Veins fine, straight, regular, not much branched. Texture fairly thin, fine, soft, elastic.

2. *Yával No. 1* (from Khándesh District).—Plant has a very low habit of growth, the internodes being very close together. Leaf slightly granulated, very narrow near base, long and narrower throughout than any other variety, widest one-third length from base, very sharp pointed. Midrib prominent and coarse, particularly near base. Veins fairly prominent, rather irregular, branched to a considerable extent. Texture thick, coarse, soft.

3. *Yával No. 2.*—Plant with a fairly low set habit of growth. Internodes short. Leaf fairly roughly granulated, large, broad, widest near base, ovate, point blunt. Midrib prominent and coarse. Veins and reticulations prominent and coarse. Texture soft, fairly thick.

4. *Shámru* from Nadiád (Kaira District).—Plant very low set habit of growth. Internodes very close. Leaf very granulated or crumpled, broad, greatest width one-fourth length from base, gradually tapers to moderately blunt point. Midrib, veins and reticulations all prominent and coarse. Texture thick, coarse, soft.

5. *Peelia* (from Kaira and Baroda Districts).—Plant fairly tall. Leaf granulated, large, widest about one-third length from base, narrow for very short distance from base, then widens abruptly, and tapers gradually to sharp point. Midrib, veins and reticulations prominent and coarse. Texture soft, thick.

6. *Kália* (Baroda).—Plant tall or moderately tall. Leaves somewhat granulated. Leaf narrow for short distance near base, then

widens, broadest one-third length from base, moderately wide, long, sharp pointed. Midrib and veins fairly coarse. Veins and reticulations numerous. Texture fairly thick and soft.

7. *Kália* (Baroda).—Plant fairly tall. Leaf crumpled or very much granulated, long, broad, narrow for short distance near base, then widens abruptly, widest two-fifth length from base, thence tapers gradually to sharp point. Midrib, veins and reticulations long, prominent and coarse. Texture thick, coarse, soft.

8. *Kari-bágláni* from Chikodi (Belgaum District).—Plant tall. Leaf slightly granulated, large and moderately wide; widest one-third length from base, very narrow for 2 or 3 inches near base, somewhat spindle shaped, sharp pointed. Midrib fairly prominent, moderately coarse. Veins not coarse and not much reticulated. Texture fairly thick, soft.

9. *Bhopli* from Chikodi (Belgaum District).—Plant tall. Leaf slightly granulated, folds double from midrib, characteristically narrow for considerable distance from base, large, long, spindle shaped, sharp pointed, resembles *sumátrá* somewhat in shape. Midrib prominent and coarse. Veins fairly prominent, but not numerous or much reticulated. Texture thicker and coarser than *sumátrá*.

Shendi-surte from Chikodi (Belgaum District).—Plant medium height. Leaves very slightly granulated, narrow near base, broadest one-third length from base, long, ovate, sharp pointed. Midrib fairly prominent and fairly coarse. Veins fairly prominent. Reticulations fine. Texture fairly soft, moderately thick.

An unnamed variety from Nadiád.

Dwarf, low set plant. Leaves very crumpled, short, very wide in proportion to length, widest one-third length from base and thence tapers slowly to a sharp point.

OPIUM OR WHITE POPPY—*Papaver somniferum.*

Gujaráti, *Afin;* Maráthi, *Afu;* Kanarese, *Afimu.*

The opium yielding poppy is believed by botanists to be a cultivated state of *Papaver setigerum*, a species which is wild on the shores of the Mediterranean, particularly in Spain, Algeria, Corsica, Sicily, Greece and Cyprus.

Origin of the plant.

The cultivated poppy was known to the Ancient Greeks, and was in India before the Aryans. It was introduced in Persia, India and China by Arabs. The crop appears to have been known in China at a very much later period than in India, but, when introduced, the spread of the drug was very rapid. The Chinese began the habit of smoking it, and the consumption got so great in China that the drug was largely imported into that country. This created a demand from India. The

cultivation of poppy is now common in China, but the quality of the opium produced is much inferior to Indian.

Distribution. The opium poppy is grown especially in Native States here and there throughout India, but its cultivation is mainly confined to three centres which yield the following opiums:—"Pátna opium" in Behar, "Benáres opium" in the North-West Provinces, "Málwa opium" in Central India and Rájputána. The cultivation of opium in the Bombay Presidency is prohibited. The crop is grown to a considerable extent in the Kadi Division of Baroda.

Cultivation restricted. I quote Duthie and Fuller as follows:- "In the plains poppy cultivation has been restricted by Government to certain well defined tracts in order to render its supervision easier, and hence its distribution is artificial, and is only partly dependent upon natural qualifications of soil and climate."

The system on which opium is grown for Government is as follows:— "Every cultivator wishing to grow the plant must obtain a written license to do so, and receives an advance in cash of from Rs. 12 to Rs. 13 per acre paid in two instalments—first, two months before the poppy is sown; and, second, one month after sowing. The whole of the produce is purchased by Government at a rate varying between Rs. 4-8 and Rs. 6 per *ser*."

Cultivation Baroda. The Baroda Government first licensed opium cultivation in 1878, and the cultivation is controlled in much the same way as in British Territory. The cultivator applies for a license for a given area. He gets an advance of Rs. 8 or Rs. 10 per *bigha* ($\frac{3}{5}$th acre) to enable him to buy seed and cultivate his land. The price of the produce is fixed at the same time. The area usually now exceeds 20,000 acres annually.

The first attempt to grow the opium poppy in Kadi was made by a Rajput who had seen it grown in Málwa. He failed. A Kunbi made a second attempt, and succeeded so well that his neighbours copied him. This first Kunbi cultivator started growing the poppy, because in a dream Máhádev offered him three handfuls of opium. This he took as a good omen, and began work.

General character of the plant. The opium poppy is an annual 2′ to 4′ high. The stem branches freely. The branches, leaves and fruit (a capsule) are covered with a whitish bloom which easily rubs off. The flowers are white (occasionally tinged purple with purple spot at base). Seeds small, very numerous in one capsule, reniform, white or black.

Climate suitable The climate of Northern India probably suits the crop better than that of any part of the Bombay Presidency or of Bombay Native States.

Cultivation in Baroda. The best soil is *gorádu*, a deep alluvial sandy loam. The crop is a *rabi* one. The season extends from October to March-April. The

field intended for opium is ploughed and harrowed repeatedly during the rains. If it is in low condition, manure is given in fair quantity—ten to fifteen loads per acre. The plant is liable to run to leaf and stalk in a highly manured field. A fine degree of tilth and a fairly firm seed bed are necessary for the best results. Before sowing, the field is laid out into beds for irrigation. The seed is carefully broadcasted at the rate of 3 lbs. per acre in October, and lightly covered with a hand rake. In order to sow the seed equally, it is mixed with powdered earth or ashes. It is best to irrigate once before sowing, and sow the seed when the beds have sufficiently dried. Light irrigation is given frequently until the delicate young seedlings are fairly established. Then the field is watered every fortnight until the flowers appear. The crop requires careful hand weeding. The stirring of the surface soil with the weeding hook (*khurpa*) is also beneficial. The first weeding is given three weeks after sowing and a second and third at intervals of a fortnight. The plants are thinned out, so that they are 8″ to 10″ apart. The young plants so removed are used as a green vegetable. Poppies are ready to yield opium when the capsules turn a light brown colour and become somewhat hard. The juice is removed from the fruit by scarifying it with a three-bladed instrument, called *náreni*. The blades are fixed ¼th inch apart, so that they make three parallel scratches on the capsule. The implement is oiled before use. The cultivator in the evening makes deep scratches in the capsule from bottom to top. Only one part of the capsule is lanced at a time. To go round the whole capsule five to eight lancings are required with intervals of one or two days between each.

The morning after lancing a gummy juice is found exuding from the cuts. The substance is crude opium. It is carefully scraped off by means of a small iron scoop, and caught in a brass vessel which has previously been oiled. The juice is carried home and stored in earthen jars, and, when all gathered, is sold to Government. The out-turn from a *bigha* is given at 10 to 12 lbs. (20 lbs. or less per acre).

The crop may also yield 200 to 250 lbs. seed per acre.

The crop is subject to many injuries. Frost is most dreaded. Dull, cloudy days and east winds are also bad. Monkeys cause much damage in the Kadi Division.

Poppy seed yields a clear limpid oil. The residue oil cake is used as cattle food. In France the crop is grown entirely for its oil seed. Poppy seed oil cake is a well known cattle food in the European trade, and the oil is largely used to adulterate olive oil, &c., and is suitable, because it is comparatively tasteless.

INDIAN HEMP—*Cannabis sativa.*

Natural order—*Urticaceæ.*

Gujaráti, *Bhánng, Gánja;* Maráthi, *Bhánng, Gánja;* Kanarese, *Bhánng, Gánje.*

Habitat. This plant has been found wild South of the Caspian Sea, in Siberia and probably in Central and Southern Russia. It appears to be wild in the Western Himalayas and Kashmir. It is acclimatized in the plains of India generally, and has gone wild in various parts, and can be found as a cold season annual in rubbish heaps and backyards generally throughout the plains of India.

Economic uses of the plant. It is cultivated in India for (*a*) as a narcotic crop, (*b*) for its fibre hemp, (*c*) for the ripe seed from which an oil can be prepared. The usefulness of the plant for each of the above purposes depends a great deal upon the character of the soil, climate, altitude, and other natural conditions of the country in which it is grown. In the plains of India the narcotic is the most valuable product. In the Himalayas and other colder parts or of high altitude probably the plant is most successfully cultivated for fibre and seed. The seed is eaten or pressed for oil, and is very commonly used in Europe as food for cage birds. The chief value of the Asiatic crop is the narcotic which it yields.

General character of the plant. The plant is a coarse tall annual, with male and female flowers borne on different plants. Stems woody at base and usually about 5 feet high, but on rich, highly manured soil much higher. Male flowers terminal and on axillary drooping panicles. Female flowers fewer, axillary, sessile. Fruit enclosed in perianth, small, smooth, brownish grey. The plant requires for the proper development of the narcotic a dry climate and a fairly light rainfall distributed throughout the season in light showers.

Distribution in the Presidency. The area is small, and has varied from year to year considerably. The total in some years is 2,000 acres, but in other years has declined to $\frac{1}{3}$ or $\frac{1}{2}$ the maximum.

In Gujarát, Surat grows a small area. In the Deccan the crop is grown in all the six collectorates, the Ahmednagar, Satára, and Khándesh areas being the most important. The cultivation in the Karnátak is very trifling, and no hemp is grown in the Konkan.

Cultivation. The Bombay cultivators are of the ordinary cultivating classes, but possess the special knowledge required to distinguish male from female flowers and the preparation of the drug.

The hemp plant requires good soil and careful tillage. It does best on fairly deep, friable, well drained soil. A soil formed in

the Deccan by the admixture of light alluvium, washed from the uplands with the mixed black soil found at lower levels, suits the crop admirably. The patches in which hemp is grown are usually situate close to the village, and are naturally manured by village sullage, &c. It is useless to attempt to grow hemp on soil which is not in good condition. If the soil is in poor condition, a dressing of fifteen to twenty cart loads per acre of old cowdung manure is required. The manure should be given in May, and then evenly spread over the surface of the land. The field should be prepared by once ploughing and repeatedly harrowing after the first fall of rain. A fine state of tilth—a friable, well prepared seed bed—is necessary. The seed should be drilled in June-July in rows 18″ to 30″ apart, depending upon the character of the soil and its condition. The seeds are small, and require very careful sowing. To secure even distribution, the seed should be mixed with fine earth or ashes before sowing. The drill should work near the surface, otherwise the small seed will be buried too deeply for successful germination. The usual seed rate is 8 to 10 lbs. per acre, but this is really more than is required. Superfluous seedlings are thinned out when they become fairly established. In really good land the rows ought to be 2 to 2½ feet apart, and the seedlings should be thinned out to a foot apart. The distance will be increased by the subsequent removal of male plants. Young hemp plants are used as a delicate green vegetable. One hand weeding at least is necessary, and the bullock hoe should be used repeatedly until the plants are so advanced in growth that they are damaged by the bullocks working the hoe. In September-October the cultivator seeks diligently for male plants. These are removed by uprooting daily as they are found. If the female flowers are fertilized, the narcotic principle is very poorly developed in the plants. A very few male plants, if left, are sufficient to fertilize the female plants in a whole field. Sufficient space should be left between female plants to encourage lateral branching. Lateral growth is induced by giving the stem near the root a half twist round, thus bruising the tissues and arresting growth for the time being. The crop is ready in November-December or December-January. If the late rains are deficient, two or three waterings from a well or other source of irrigation may be required. The crop is harvested by cutting all flower bearing branches along with about one foot of the branch stalk.

Preparing drug.

A beaten threshing floor is prepared, and on this the flower bearing branches are left to exposure and the influence of dew for one night. Next day these branches are heaped in small heaps with the tops in the centre, and are trampled and trodden down by men. Layer is added

to layer, and the trampling repeated daily for four days. The result is that the flower heads are pressed flat, and *gánja* is obtained by winnowing and picking these flower heads by hand from the chaff and broken flower heads, which mixture is known as *bháng*. *Gánja* and *bháng* are separately stored in gunny bags. In the Ahmednagar District the resinous substance (*charas*) which adheres to the feet and hands of men who trample and press *gánja* is scraped off, and saved for private consumption, but not for sale.

Gánja.

Gánja as prepared in the Bombay Presidency is considered somewhat milder than the Upper India drug by those who have smoked *gánja* in Upper India, as well as in the Deccan. The mildness is attributed to the practice in the Deccan of harvesting the crop at a more immature stage than is customary in Upper India. In the Deccan the use of *bháng* is much more limited than that of *gánja*, the latter for smoking being much the more important drug.

How *gánja* is smoked.

Gánja is not subject to any special treatment until it passes into the hands of the smoker who breaks it into small bits, removes seeds, leaves, and foreign matter if there be any. He then places the broken *gánja* in the palm of his hand, and pours water over it three or four times till the water runs off clear, kneading the *gánja* at each watering. If properly done, the process takes ten minutes. During the process the *gánja* gets sticky. It is then squeezed free of water between the two hands. A small cake is left, from which pieces are broken and mixed with an equal quantity of tobacco, and smoked in an ordinary native pipe. In very rare cases *dhatura* or nuxvomica is smoked with *gánja*, and the admixture, of course, increases the intoxicating effect.

Bháng.

Bháng as sold in the bazar is first picked to remove pieces of stalks and other impurity, and then washed with water. Subsequently it is ground into a fine paste on a grind stone with a few grains of black pepper. Hindu ascetics prefer a mortar and pestle of *nim* (*melia azadiractes*) to a grind stone. The paste is stirred in water and strained through cloth, and the filtrate drunk either with or without sugar. This is the simplest and cheapest form of *bháng* for drinking. Those who can afford it add ground almond kernels, and flavour with cardamoms, &c.; and well-to-do, habitual drinkers buy raw *bháng* in quantity, boil it in water for two or three hours, and then wash it clean of all impurities. It is then dried and stored for use. Subsequently, as required, it is ground into powder, infused with water, and drunk as described above. *Bháng* is never drunk without a seasoning of black pepper, but often it is seasoned with almonds or mixed with milk sweetened with sugar or sugarcandy, and flavoured with some or all the following articles of

the *bhâng masâla*:—Poppyseed, rose petals, fennel, nutmeg, cardamoms, black pepper, and *kasni* seed (*Cichorium endivia*).

Charas is used in smoking only, and its use for this purpose in the Deccan is rare. As a rule, *bhâng* is not smoked unless the smoker of *gânja* is hard pressed for supply of his favourable drug. *Charas* requires no preparation before its use. It is simply made into small pills, and smoked either with *gânja* or tobacco according to the choice of the smoker. *Gânja*, *bhâng* and *charas* deteriorate with keeping. They keep good for a year, but deteriorate in intoxicating qualities afterwards. (1) *Charas.*

Messrs. Duthie and Fuller in their "Field and Garden Crops" describe the separation of the fibre from the hill crop of India thus:— The fibre from hemp.

"The stalks are then laid in water to promote fermentation which will allow the bark to strip off. On being taken out, they are beaten with mallets to loosen the bark which is then detached by hand in strips, and, after a second beating, breaks up into fibre which is made up into hanks for sale. In some places the fibre is boiled in potash, and bleached before spinning. The principal things manufactured from it are hemp cloth (*bhângra* or *bhângela*) and the ropes which are used for swing bridges over hill streams. The cloth makes an admirable material for sacks, and is largely used in the grain trade on the Nepaul frontier, and latterly in the export of potatoes from Kumâon. It also furnishes a large portion of the hill population with a characteristic article of clothing—a hemp blanket, worn, like a plaid, across the shoulders and fastened in front with a wooden skewer."

The Cultivation and Manufacture of *Gânja* in Madras.

(By C. Benson, Esq., M.R.A.C., Agricultural Department, Madras.)

The true hemp plant (*Cannabis sativa*), though grown here and there in most parts of the Presidency in backyards, is found as a regularly cultivated field crop in only two localities, *viz.*, in the Malayali villages on the Javadi Hills in North Arcot and in one or two villages in the Bapatla Taluk of Kistna District. It is also raised to a certain extent in the hilly parts of Vizâgâpatam and Ganjam, but there seldom more than a few plants are grown by each person.

The *Javadis* are a low hill range, covered with jungle, amongst which the Malayali villages lie scattered, few of them consisting of more than three or four huts. Each village has a small patch of land

(1) The notes are chiefly extracts from evidence submitted to the *Gânja* Commission by Mr. Yashvant Nilkanth, Superintendent of the Office of Survey Commissioner and Director, Land Records and Agriculture.

cleared for cultivation near by, and there, in almost all cases, a plot or two of hemp will be found growing. The Malayalis claim to be Vellalas, but, except for purposes of trade and barter, have little or no connection with the people of the plains. They also claim to alone possess the knowledge necessary for the manufacture of *gánja*—a practice which has been carried on, they state, in these hills from time immemorial. They attribute the fact that the growth of the crop is confined to the hills merely to the ignorance of the people of the plains, and state that, if the latter knew how to deal with the crop, they would easily grow it outside the hills.

On the hills cultivation is carried on in small plots, the natural fall of the ground preventing any considerable tolerably level area being found in one place, although to a certain extent the plots are terraced. In these plots the Malayalis raise the ordinary dry food grains of the country for their own consumption, and with them the hemp plant alternates, hemp not being ordinarily taken on the same land in two successive years. The soil is free, friable, and open, derived directly from the rocks on which it rests, thoroughly well drained, and appears to be fairly fertile. For hemp it receives a heavy dressing of cattle dung, without which it is said to be hopeless to raise the crop. This manure is spread on the surface in May or June before the first rains allow of ploughing being begun. As soon as the land is sufficiently moistened, it is ploughed, and the operation is repeated three or four times at convenient intervals until some time in July, when the seed is sown. Sowing is done by dropping the seed, at the rate of five or six seers per acre, in a furrow opened with a plough, the seed being covered with soil drawn over it by the feet of the sower. The seed is sown in rows about 3 feet apart, and during the growth of the crop the spaces between the rows are worked and kept clean by ploughing and weeding. The young plants appear in about a week after sowing, and when about three weeks old they are partially thinned out, and when they reach to a foot high they are earthed up by means of a plough which is run along on either side of the rows. This latter process, aided by hand weeding at intervals of about a fortnight, thrice repeated, keeps the whole land clean.

When the crop is about four months old, the anxieties of the cultivator commence, and the crop has to be examined carefully and frequently, so that any male plants—called female by the ryots—may be detected and removed. Detection of the male plants is only possible when the flowers appear. Their entire removal is absolutely essential to securing a crop of *gánjá*, as otherwise the whole crop runs to seed. The removal of the male plants is a continuous process

going on as the plants are detected. Notwithstanding this care, a certain amount of seed actually sets.

Some time early in January the harvest begins. It continues up to March. Plants are ready for cutting as soon as the leaf turns yellow, and begins to drop. At the same time the spikes of female flowers also turn yellow. The crop is never cut on a damp or cloudy day.

In harvesting, the ripe plants are cut bodily, tied into small bundles, and carried to the threshing floor of the village. There the spikes are stripped off the stems, with a few of the leaves, and the stems are thrown away. The material thus collected is spread out on the floor in the sun during the middle of the day for three, four or five hours, and then loosely rolled in the hand to work out such seed as may have been formed and to break up the leaf that remains. This working also causes the spikes to stick to one another to some extent. The broken leaf is then winnowed out, collected, and powdered.

The manufacture then begins. A closely woven bamboo basket is taken and dusted inside with leaf powder. Into it is placed a layer of the spikes an inch or an inch and-a-half deep. The spikes are then trodden under foot by a man working round and round on his heels in the basket four or five times, the man supporting himself on a stick, whilst the basket is held steady by two others. If the basket be large enough, two men do the treading, grasping each other's shoulders to steady themselves. Layer over layer of the spikes is thus made in the basket till it is full, each layer being separated from the next by a little leaf dust. When the basket is full, its contents are turned out on a piece of flat hard ground, and on the top of the pile a large flat stone is placed, upon which are piled other stones to weight and compress the heap. The weights remain thus till next morning at about 8 or 9 A.M., when each layer is taken out separately, broken into small bits, and spread in the sun to dry. Whilst spread out thus, the pieces are trampled on with the heel and turned over from time to time to secure proper drying. In the evening the pieces are again re-piled and weighted, and next day again turned out to dry, the process being repeated till the whole is thoroughly dried.

Great importance is attached to the thoroughness of the treading, the sufficiency of the pressing, and the completeness of the drying, the quality of the drug being said to depend on the manner in which these processes are carried out. If the cakes are not dried sufficiently, they appear green, and are of inferior quality—good *gánja* being brown.

When fully cured, the cakes are stored in the ryots' houses, where they are packed in date mats in bundles, each containing twenty visses (say, 60 lbs.), and kept under pressure till sold to dealers.

In *the Kistna District*, the soil, the conditions under which the crop is grown, and the method of manufacture all differ entirely from those described above, as much as they do from the practice in Bengal; according to Dr. Prain's description. It is only in one village, Daggupád, in the Bapatla Táluk, not far from the borders of Nellore, and about fifteen miles from the sea coast, that any considerable area of the crop is to be found, although a little is also grown in one or two of the neighbouring villages. The country is a wide open plain of black cotton soil, and from its appearance badly or poorly drained. The soil is not particularly stiff for the description concerned, being, in fact, a good stiff loam, and contains a considerable amount of *kankar*. On the land on which hemp is grown, the common crops with which it usually alternates are noted on the margin. The crop is grown in open fields, some near to and some at a distance from the village, but all reasonably accessible. In some cases it is cultivated, and handled by the ryot who owns the land, but more frequently the cultivation of the land and all the cattle labour required is supplied by the ryot, and the planting and handling of the crop is undertaken by others—chiefly Mahommedans, of whom there is a considerable settlement in this village. Here, as in Bengal, the plants are raised in seed beds and planted out, but except at the time of planting no irrigation is resorted to after the crop is put out into the field.

Jonna (*Sorghum vulgare*).
Variga (*Panicum miliaceum*).
Dry paddy.
Coriander.
Tobacco.
Indigo.
Chillies.

The seed beds are usually made on the bund of a tank, and are 6 feet wide by 60 feet long. The soil of these beds is dug up with a crow-bar, and reduced to a fine tilth and levelled. Seed is thus sown at the rate of four or five seers (of 85 tolas) to a bed, two such beds supplying plants sufficient for an acre of land. The seed is covered with earth strewn over it by hand. The bed is then watered by hand, and the watering is repeated daily for about two months as required. The sowing takes place in August. When the plants are 2 feet high, they are topped off, and in a few days numerous side branches are put out. The plants are then transplanted into the field.

Land intended for hemp may have carried a crop of hemp in the previous year—19 out of 118 acres planted in Daggupád this year (1893-94) being said to have carried hemp in 1892-93—but more usually the crop is alternated with one of those mentioned above. If it follows hemp, heavy manuring is necessary. Cultivation of the land for the crop usually begins with ploughing in July, and between them and October it is ploughed about three times and finally worked with

the three tined grubber (*gorru*, or seed drill used without its seed hopper and tubes). It is then marked off in 2 feet squares with a marker, similar to the *guntaka*, or scuffle worked without its share. At the angles of each square four or five plants are dibbled into a hole made with a stick, and they are watered to set the plants. The crop is planted out in October.

The land intended for this crop is manured either with cattle manure or by sheep folding, the application of manure being considerable when the land carries hemp successively year after year.

A month after planting the fields are hand weeded, and about a fortnight later a plough is run between the rows, and the plants are earthed up slightly. Two months after planting out, flowering begins, and then the removal of the male (here as elsewhere termed *female*) plants begins. They are cut off near the roots and thrown away. This work goes on continuously as long as male plants are found.

About February the plant begins to ripen, and the harvest commences. It goes on till the end of March. The plants are cut bodily with the sickle, and are laid out in the field, where they lie for three days to dry in the sun. On the fourth day they are tied into small bundles of about ten plants each, and then piled, head and tail, in the field. The heaps are opened, and the bundles re-piled next day, the process being repeated over several days. When the quantity to be dealt with is small, and space allows, the bundles are carried to the grower's house and there piled; but in all cases the crop is finally carried to the house, and a month later the spikes are removed. Each spike is plucked off by hand, and then they are spread out on a hard floor in the open for one night in the dew to soften and become pliable. In the morning the spikes are collected and stored in large gunny bags, being packed closely therein by a man treading them down into the bag. The produce is then ready for sale, and may be kept for as much as two years.

In both localities it is stated that of late years the area planted with hemp has been reduced, the price offered for *gánja* having fallen with the restriction of the demand owing to the introduction of the system of licensing retail vendors.

A few years ago the crop was also grown to some extent in one village in the Pulivendla Táluk, Cuddapah district, but its growth there has now been abandoned. It was then grown as a garden crop, in rotation with garden *korra* (*Setaria italica*) or garden *rági* (*Eleusine coracana*), the plants being raised in seed beds and then planted out. The method of manufacture adopted there appears to have resembled that still followed in Kistna.

ARECA OR BETEL-NUT OR SUPÁRI-PALM—

Areca catechu—Linn.

Natural order—*Palmæ*.

Tribe—*Arecineæ*.

Gujaráti, *Sopári*; Maráthi, *Supári*; Kanarese, *Adike*.

Habitat. This palm is a native of Cochin-China, Malayan Peninsula and islands. It is cultivated throughout tropical India, but does not thrive at any great distance away from the sea.

The gardens Kanára. Betel-palms, cardamoms, and pepper are the chief crops grown in the garden lands of Kánara. In old established gardens there may be a few jack fruit and cocoanut trees, also plantains, limes, coffee bushes, and pineapples. These gardens are chiefly found in Sirsi and Siddápur Tálukas, and in the whole collectorate extend to some 17,000 acres. They generally occupy the bottom lands of narrow valleys. The most favourable situations are in valleys which have the slopes on both sides fairly extensive, moderately steep, and covered with forest growth. The forest growth gives beneficial shade and shelter, and supplies the gardens with branchwood, leaves, and litter for manure and other purposes. The garden land extends usually in a narrow strip along the course of any particular valley, and is sub-divided according to ownership. Bottom land which is open and cleared appears to be more suitable for rice beds than for spice gardens. Some garden occupants also own rice land, but most commonly they only cultivate garden land. An owner may own three or four acres, sometimes more, often less.

The gardeners. All garden owners are *Haviks*—a shrewd and hard working, well behaved class among the Bráhmins. They are supposed to have come originally from Mysore. Their methods of cultivation are almost identical in all gardens, and presumably are ancient in origin. The methods adopted are successful in practice, and although they appear at first sight extraordinarily antiquated to a casual onlooker, they may, like other time honoured Indian practices, be found on full enquiry the most suitable for the existing natural conditions of the district. The *Haviks* are well-to-do, as evidenced by their commodious, well built houses which in many cases are roofed with Mangalore tiles.

How the gardens are arranged for cultivation. The narrow strips of spice gardens follow the course of the old *nálas* which drained the valleys before the gardens existed. When the gardens of any particular valley were first formed, the bed of the *nála* was levelled and also the bottom land along its course. Since that time the slopes on either side have been gradually cut away, and many of the old gardens are now bounded laterally by almost perpendicular cuttings 10′ to 20′ in height. These cuttings present a complete barrier against trespass by man or beast, and shelter the gardens from storm and wind. The occupants' house and buildings are close to the garden,

above the cuttings, usually in a cosy fairly dry situation. A garden is entered by descending a steep narrow pathway or by rude steps which lead to a plank bridge over a ditch at the bottom.

Rainfall; drainage.

The rainfall of the district is heavy, and the positions of the gardens are such that much drainage water must pass through them. Drainage is thoroughly arranged for by main ditches cut along the course of the garden strips and by cross minor ditches which carry water to the main drainage channels. The main channels are bridged here and there as required by long slabs of stone or by three or four pieces of palm stem placed side by side. The heavy rainfall and the flood of drainage water in the monsoon undoubtedly wash much of the garden land away, and more particularly so if the soil is not of a particular kind.

Soil suitable; how renewed.

The most suitable soil is called locally *kágdáli*. This is a yellowish red or reddish brown earth which usually exists in deep beds as the side cuttings of the gardens show. In these cuttings rock of a soft nature sometimes obtrudes a few feet below the surface, but more often the whole depth of cutting is soil-like in character, and appears in layers which vary somewhat in consistence. There are no definite lines of demarcation between layers; but near the original surface, generally, there is sometimes a gritty or gravelly section which is considered inferior. Further down there is a layer which presents a shaly appearance which deceives the eye. At first sight it appears hard, durable or rocky, but a piece can easily be broken off by the hand, and, if squeezed or rubbed, crumbles into an impalpable powder which feels moist and soapy. This soil material as seen in the cutting has a peculiar metallic lustre, but when crumbled is simply a fine argillaceous yellow earth, extremely retentive of moisture, and which under pressure becomes consolidated, so that running water does not readily remove it. It is easy to understand that a soil of this class is suitable for a spice garden. It does not matter much whether the soil is naturally fertile or not, because the yield of the crops grown is mostly affected by the quantity and quality of manure directly applied. As regards the soil, the chief point is that it must be of such consistence that it can withstand the denuding effect of flood water and be so retentive of moisture that little or no irrigation is required in the fair season.

Irrigation.

In many gardens irrigation is not required even in the hot weather. At this time a trickling stream fed from natural springs may be seen running along the main channels or a perennial *náḷa* passes by the main channels through the garden. The soil is thus kept continuously moist. In such gardens ferns and mosses in great profusion and variety grow along the drainage channels. In other gardens not so favourably situated a little irrigation may be required in March, April,

and May, and this is arranged for from a tank or tanks usually built of stone and not very capacious, which tap the waters of natural springs.

How the gardens are laid out.

In laying out a garden the soil is first levelled, and then the drainage channels are made. The main channels are about 4 feet deep and 4 or 5 feet wide at the top, with sides having an easy slope to the bottom. The minor cross channels are 1 foot wide and about 18″ to 2′ deep. These channels are exactly parallel. They are distant from each other 12 to 15 feet. The space between is called *bharan*. The *bharan* has a rounded surface. It is highest in the middle, thus rain water drains freely to the channels. A pathway runs along the middle of each *bharan*, or rather by usage the middle of each *bharan* becomes a pathway. On each side of the pathway, in old established gardens, a line of alternate betel palms and cardamoms are found with pepper plants trained on the stems of the palms. The palms are 6 to 8 feet apart in the rows. It takes, however, many years of patient labour before the garden gets to this stage. When a new garden is made, the *bharans* are thoroughly dug and weeded. Plantains are planted along the water courses. They give some direct return for expenditure incurred, but the object in planting them is to provide shade for the betel palms. When the plantains afford sufficient shade, pits 2½ to 3 feet square and 2½ feet deep are made. Leaf manure and pieces of plantain stems are put in the bottom of the pits, and then excavated soil partly filled in. The young palm trees 4 or 5 feet high and three or four years old are planted in these pits, and sufficient of the excavated earth put round and pressed on the roots to keep the plants straight.

Cultivation.

The palms are raised in seed beds, and are once transplanted before they are planted out permanently. The first seed bed is carefully prepared, the soil is dug, broken fine, and mixed with leaf mould. Fully matured nuts from old trees are specially selected for planting. These are planted about 9 inches apart in April. The seed bed should be kept thoroughly moist. The shoots appear in June. The seedlings are transplanted in October into any moist place in the garden or along the water courses about 2 feet apart, and remain thus until permanently transplanted. This permanent transplantation is usually done towards the end of the rains. In the following March the trees are manured with leaf manure, and the manure is covered with fresh cut branchwood which is partially withered, but which retains the leaves. The object of placing a layer of small branches above the manure is to break the force of heavy rain. The rain soaks through the brushwood, moistens the manure, but does not carry it away as would be the case if it were uncovered or covered with soil or in any other ordinary way. The betel trees are manured as described every second year, and come into

bearing in ten years or so. The plantains are maintained for some years after the betel palms are permanently planted, but in time are removed, and the cardamoms are planted between the palms, and on the stems of the latter pepper vines are trained. The *bharan* gets more or less washed away during each monsoon and the channels more or less damaged. This to some extent is prevented if plantain leaves, dried grass, and other available rubbish is put on the surface. But, despite any precautions, the *bharan* is more or less denuded. The earth from the pathway is, therefore, moved to repair the drainage channels, &c., and new *kágddli* earth is brought in in head loads from the cuttings which border the gardens, and placed along the centre of the *bharans*. This renewal is necessary at least every third year. It is an expensive operation, but if the excavation from the cuttings is done in a systematic manner, the area of the garden can be gradually extended. The trees in the first plantation of betel palms generally stand wide apart, but, as they grow, other young trees are planted between them. A nursery is always maintained to provide young trees for this purpose and to replace those which die from time to time.

Yield.

Betel trees are known to fruit freely for thirty of forty years, and there is a popular belief that they are sometimes profitable much longer. On an average each tree has two bunches of fruit, sometimes three or four. But two good bunches yield as much as three or four inferior ones. The size of the bunch depends upon the manure used and upon the rainfall. A good bunch gives 200 to 300 nuts, and a specially good one about 400. With unfavourable rain or cloudy weather in April or May many of the young nuts fall off, and a smaller number of nuts on each bunch reach maturity. The trees produce flowers in March and April, and the nuts are ripe in November or December, but to some extent the trees produce flowers and fruit out of season. Immediately below each bunch there is a frond or leaf. It with its sheath remains attached to the tree for about two months after the inflorescence comes. Then these leaves fall to the ground. A few additional leaves fall during the monsoon. The sheaths of the leaves are a valuable product in the garden economy. They are used to provide hoods for protecting the branches of betelnuts from the rain. If unprotected, the nuts rot. Two sheaths are used to make one hood.

How sheltered.

The sheaths are skewered together to form a hood by means of thin pieces of split bamboo in a manner which is easy to demonstrate, but difficult to describe in writing. The hood is made adjustable in a very ingenious manner, and when it is bound round the bunch with thongs of plantain bast, it efficiently wards off rain.

The hoods are made and tied on by professionals who come from Mysore Territory and below the Ghâts. A good workman can make 250 hoods per day, and is paid Rs. 2 per 1,000. This operation and tying them on costs at contract rates Rs. 10 to Rs. 12 per 1,000 bunches and two meals per day. The men do not ascend and descend each tree. When once they have climbed up, they by means of slight exertions swing the tree and deftly catch hold of another and rarely descend to the ground for hours. These expert climbers also gather the fruit by cutting the bunches from the stem, getting Rs. 4 per 1,000 bunches and three meals per day. Some garden owners or their regular servants are experts in making hoods, in adjusting them, and climbing the trees. It is extremely interesting to note the manner in which the work is done. The climbing in the fair season looks extremely simple and easy to an onlooker, but in the monsoon with falling rain the tall smooth stems are slippery, and the ascending process is much more difficult. The climber first ties his feet together round the insteps with strong bands stripped from the sheath and leaves of the betel palm. This helps him to grip the stem with his feet. He carries with him slung round the neck a wooden rest on which to sit when he gets to the top. This rest is shaped like a two armed pick, and through a hole which corresponds to the shaft hole of a pick, a rope is passed and spliced, so that it is endless. When the fruit is reached, the rest is unslung and attached to the tree. The doubled end of the rope is passed round the stem, and is long enough to pass over the two prongs of the rest, and, when drawn tight, secures the rest to the tree. It does not slip down, because the circumference of the stem increases downwards, and the rings in the tree offer obstruction to sliding or slipping. The operator sits resting one thigh on each wing of the rest, and one hand at least is comparatively free to fix the hood over the bunch of nuts or to sever the bunch when ripe from the stem. The bunches when ripe are lowered to the ground by being slung to a rope over which they ride. Any one who has seen a bunch of betelnuts can easily determine how the bunches are placed on the rope. They rapidly slide down, and are caught by a man who holds the end of the rope at the ground. The stretched rope is held inclined at a considerable length from the tree.

How gathered.

How husked.

The bunches on a tree ripen unequally—the lowest bunch first, the uppermost last. Moreover, in the same bunch some nuts may be ripe and yellow and others unripe and more or less green. The ripe nuts are much the same size and shape as small apples. The outer skin is yellow, smooth and shining. The inner husk is very fibrous and not easily removed. The first process in preparing for

market is to remove the husk. This is done very deftly by means of the *katti-gatti*. It is an implement like a sickle. It is fixed at the heel end of its blade securely into a hole near one end of a plank, somewhat in the same way as if it were fixed in a handle. The back of the blade at the bent part rests in order to steady it in a notch in the plank. The blade of the sickle is presented in an upward position opposite to the workman. He sits on the other end of the plank. The plank is about 3 feet long, 1 foot wide, and 1½ inches thick. The husk from each nut is cut out in sections. A nut is grasped in the palm of the hand, and pressed against the point and blade. The husk is thus cut through to the nut, then by leverage a section of husk is jerked off. The nut with remnant of husk is turned in the hand so quickly that to an onlooker the action appears involuntary, and another section of the husk is removed like the first. With four or five movements of this sort the whole husk is removed. A clever workman can husk 5,000 nuts per day, but 3,000 is nearer the average. The contract rate for the work is one anna per 1,000 with two or three meals per day. The husked nuts are scraped free of fibre, also by the *katti-gatti*. The process is essentially a scraping process, and costs at contract rates 1½ to 2 annas per 1,000.

Boiling the nuts.

The scraped nuts are next boiled for about two hours in fairly large copper pots. A handful of lime or of the ash of the bark of *matti* (*Terminalia tomentosa*) is added to the water. The presence of lime causes the water to become red or red brown in colour as the boiling proceeds. The water also becomes thick with a resinous extract from the nuts. The boiling is continued until the eye bud or germ of growth from each nut comes out or becomes absorbed in the extract. The nuts are removed by a long handled ladle (*zára*). The ladle has perforations in its bowl, which allow the extract to drain from the nuts back into the pot. The extract is again and again used for boiling fresh supplies of nuts, pure water as required being added from time to time to prevent the decoction becoming too thick and concentrated. The extract after being used for boiling repeatedly becomes deep red brown and thick. It is then emptied into another broad mouthed vessel which is placed under full exposure to the sun. The mass by evaporation thickens, and "Areca catechu" or *kossa* is the product. The nuts after boiling are dried in the sun, and sorted into three kinds—*chikni*, *betta* and *gotu*.

Variety.

Chikni.—These are unripe fruits got mostly from the upper unripe bunches of the tree. They become flat when boiled, and when cut are light coloured and agreeably flavoured. They sell by retail at a high

price, but by the growers are usually mixed with the other sorts to ensure a satisfactory sale of the whole produce. These nuts after exposure to the sun are again soaked in the red extract, a basketful being immersed at a time. They are again exposed daily to the sun for four or five days, but are gathered up at night, otherwise they get dark coloured. The nuts are exposed to the sun on cane matting spread on a *mandap*. Sometimes bamboos or other means of support are placed over the inner court of the household, and the matting spread over this frame work. The nuts when dry are ready for market, and should be shining and bright red brown in colour.

Betta.—These are ripe nuts. They are dried after the first boiling and then hand rubbed with fairly thick extract to which 3 or 4 per cent. of lime has been added. This tends to deepen the colour. The process may have to be repeated two or three times. The colour becomes fixed by drying in the sun after hand rubbing. When ready for market, they are somewhat lighter coloured than *chikni*, and not so glossy or shining. They are rounder and larger.

Gotu.—These are fully ripe or overripe nuts. They are usually fairly well coloured by the first boiling, and after exposure to the sun for several days are ready for market. The colour may be deepened and improved by the same means as described for *betta*.

The three varieties are usually packed together by the cultivators in sacks. Sirsi and Kumta are the chief markets. Ordinary prices for the three varieties are :—

Value.

Chikni ...	Rs. 6 to 7	per mannd of 48 seers of 20 tolas.	
Betta ...	„ 3 to 4	do.	do.
Gotu ...	„ 2 to 2½	do.	do.

Betel palms are not much affected with disease. A borer does considerable damage. The borers cut a tunnel from the root upwards, and in time reach to the growing top. The damage there done is so considerable that the top withers, and, when wind blows, breaks off and falls to the ground.

CARDAMOMS—*Elettaria Cardamomum*—Matton.

Natural order—*Scitamineæ*.

Gujaráti *Elchi;* Maráti, *Veldode;* Kanarese, *Válakki.*

Habitat and general character of the plant.

This plant is indigenous in West and South India, and is found plentifully in the rich moist forest soils of Kánara, Mysore, Trávancore, &c. It is a perennial herb. A full grown healthy plant is 6 feet or more high. The leaves are lanceolate, narrow, long, and have rather long petioles. They grow somewhat like ginger from rhizomes. The

inflorescence is a spike, and it grows on a scape or leafless stem which springs from the rhizomes. The scapes grow horizontally, and spread over the surface of the ground. The fruit, which is the commercial product, is a three celled triangular capsule with a yellow white leathery covering which encloses numerous small black angular seeds. These have a fragrant taste and aromatic odour. The rhizome increases in size from year to year, and an old plant, therefore, produces a larger number of flowering stems and leaves than a young one. The leaves, &c., die down annually. New growth springs up. The plant can be propagated by sub-division of the rhizomes or from seed.

Kánara gardens and soils.

The crop is extensively grown in the betel palm and pepper gardens of the Sirsi and Siddápur Tálukas of Kánara. It thrives under the same conditions of soil, &c., as betel palms and pepper, but by preference is grown in a cool, very shady garden with soil kept continuously moist by favourable position. The essential conditions for successful cultivation are :—

(*a*) A soil of loam or clay loam consistence kept by favourable position moist, but not wet at all seasons.

(*b*) The garden should by its natural situation be protected from strong winds, and shade trees should be provided.

Cultivation.

If rhizomes are used for propagating the crop, they are sub-divided, and the sub-divided portions planted with their leaves attached in pits. The pits should be 18″ square and deep, and be re-filled with the excavated earth mixed with a good portion of leaf manure. The rhizome should be lightly covered with soil, and on no account be deeply buried. In Kánara the crop is chiefly raised from seed. The seeds are small, and therefore to secure even distribution in the seed bed should, before sowing, be mixed with fine ash. A well prepared seed bed with smooth, friable, well manured soil is required. The manure should be old and thoroughly decayed, so that it can be crumbled into a fine powder. Manure of this class, if mixed freely with the upper soil, gives the degree of tilth most suitable for germinating the small seeds. Leaf manure is best. The seed when sown should be lightly covered. A bed 8′ × 4′ requires about 2 tolas of seeds. Some authorities recommend that the seed before sowing should be artificially germinated in folds of cloth or flannel kept moist, but not too wet. The seeds as soon as they have struck should be shaken off the cloth on to the surface of the seed bed and lightly covered with fine soil. The seed if sown in the usual way takes a considerable time to germinate—usually a month. The sowing season in Kánara is in September-October. The beds require protection from sun or rain. This can be accomplished by the shelter of a raised platform covered

Seed bed.

with branchwood. The platform should be 3 or 4 feet high. The shade and shelter thus afforded is beneficial during the whole period during which the seedlings occupy the seed bed. The seed beds can be sufficiently protected from rain by placing branchwood immediately over the surface. This is usually the only protection given if the seed bed is otherwise naturally well sheltered. The leaves and branches of the *nelli* (*Phylanthus emblica*) are considered best. The reason why they should be considered superior for the purpose is perhaps open to conjecture. It is confidently asserted by the cultivators that the leaves and branches of this tree and other trees common in the district prevent insect attack. The leaves, fruit and bark of such trees contain tannic acid, astringent resins, and essential oils, and therefore it is possible and perhaps probable that the presence of such branchwood and leaves in contact or close proximity to young seedlings may be poisonous or disagreeable to insect life, and may deter insects from causing damage to young seedlings.

Seedlings, if they come up thickly, should be thinned out. The plants that are left should remain in the seed bed for four or five months. The beds must, in the meantime, be kept moist. Rice beds adjoining the garden are used sometimes as a nursery when the cardamoms are first transplanted. Water must be available. A series of narrow channels are cut in the rice bed parallel to each other and 2 to 2½ feet apart. The excavated soil is put on the spaces between the channels. Thus flat ridges and narrow channels are alternately formed. The cardamom seedlings are planted on the ridges, two rows on each and at a distance of 9″ to 12″ between plants. A *mandap* is erected about 5 feet high, of light bamboo or other available material. Palm leaves are spread on and tied to the bamboos, and these give sufficient shade and shelter. The irrigation water is, in the fair season, so distributed that it trickles through all the channels continuously. The ridges are thus kept sufficiently moist, but not wet. In the monsoon the irrigation and drainage water must be directed as far as possible away from the nursery. The seedlings are kept in the nursery for fifteen to eighteen months. They are then about 4 feet high.

Planting.

Cardamoms are planted permanently in the garden at two seasons—from March to June or from September to October. They are usually planted in the same lines as the betel palm and intermediate between two trees. Pits 18″ square and 18″ deep are dug. Part of the excavated earth is returned to the pit mixed with leaf manure, the seedling is planted, and the pit filled up nearly level with leaf manure, but the rhizome and roots should not be deeply planted. The leaves should be supported by one or two bands of plantain bast tied, in the case of each plant, to a stout

wooden stake securely fixed upright in the ground. The leaves would otherwise be beaten down by wind or rain. The soil of the *bharan* round each cardamom plant should be regularly dug and weeded. It is asserted that vegetation of any kind does not freely grow under cardamoms. Each plant gets leaf manure in March and April annually if the supply is abundant, otherwise only every second year.

Yield.

The plants are in bearing the year after being planted, but do not yield much the first year. The flowers come somewhat irregularly in April and May. The fruit forms during June and July, and in heavy rain should be protected by a light covering of leaves and branchwood. The capsules ripen irregularly, but mostly in September and October. Those on one scape should be collected as they ripen. They are ripe when they begin to change colour from green to yellow, and at this time should be full and firm. If the capsules are left until fully ripe, they split and shed the seed. Each capsule should be severed from the scape and not plucked. A portion of stalk should be left on each capsule. If plucked, the pressure of the fingers may burst the fruit. The fruit when gathered is dried in the sun for two or three days, and then hand rubbed in the sun to remove the dried calyx attached to the apex of each fruit. The drying should be gradual. Full exposure to the sun may cause the pods to split, and this damages the spice considerably. The capsules lose during dryage considerable weight and bulk. They are during exposure to the sun, to some extent, bleached. When quite dry, the produce is sold to dealers. The price ranges from Rs. 40 to Rs. 75 per maund of 48 *sers*, each of 20 *tolas*.

In a fully stocked betelnut garden there can be 300 to 400 cardamom plants per acre. A well grown, healthy plant may yield up to ½ lb. of dry cardamoms. But on the average the outturn is much less, often not over 4 *tolas* per plant. Light showers in April and May are favourable to a good crop, but numerous risks attend the cultivation of cardamoms.

Bleaching

The dealers bleach the cardamoms for certain markets, also sort and pack the produce suitably. The water of a well at Háveri on the Southern Máratha Railway (Dhárwár District) is supposed to have special virtues for bleaching and improving the flavour of cardamoms. Mr. E. C. Ozanne describes the various processes as under :—

"Water from the well is drawn and taken to a suitable room. A large earthenware vessel is filled with the water, into which pounded *antalkái* (the fruit of soapnut, *Sapindus trifoliatus*) and *sikekái* (*Acacia concinna*) in the proportion of 2 lbs. of the former to ¼ lb. of the latter for about 5 gallons of the water are placed and well stirred. Another vessel contains a strong solution of common soap in the water of the

well. The mixture containing 2 lbs. of pounded soapnut and ¼ lb. of *sikekái* suffices for 5 maunds (1 maund = 26 lbs.) of cardamoms.

"Two women seated on tripods place a wide mouthed earthenware vessel between them, the washing tub as it may be styled. Eight *lota*-fuls of the well water (a large supply of which is kept at hand) are poured into the tub and three *lota*-fuls of the soapnut or *sikekái* mixture. The *lota* holds about one quart of water.

"The tub then receives a basketful of cardamoms weighing 10 lbs. The two women plunge their hands into the tub, and stir vigorously for about one minute and then suddenly rest for about the same length of time, and again stir for another minute. A thick lather results. This completes the first washing. The cardamoms are baled out by hand and transferred to a basket, where they remain a few seconds till the water has drained off. The basketful is received by two other women sitting on tripods with a washing tub between them. This tub contains 7 quarts of the pure water, 1 quart of the soapnut and *sikekái* mixture, and one of the soap solution. The cardamoms are stirred as in the first washing with the same interval of rest, and are baled out into another basket. When the water is drained off, the washed cardamoms are thrown on to a mat. The heap becomes large after a few hours' work. A woman is exclusively in charge of it, and continually sprinkles the well water over it. She is relieved at night by another woman who sprinkles the heap till morning, once every half hour.

"Next day, when the sun has risen, the heap is carried to the flat roof of the house, and the cardamoms are spread on mats for four or five hours to dry. The next operation is to nip off the short stalks. This is done by women sitting in the house. Each woman has a large pair of English scissors. She squats on the floor and rests her right hand which holds the scissors on the floor and feeds the scissors with her left hand. The pace at which this nipping is done astonished me. The stalk is very small, and care must be taken to cut it off without injury to the cardamom itself. I saw an old woman nip ninety cardamoms in one minute.

"This done, the sorting begins. The small ill shapen cardamoms are separated, and only the well-rounded ones packed for export to distant markets. A woman sorts a maund per diem.

"I must now return to the first washing. The mixture in the tub, after the first basketful has been baled out, is replenished by two or three quarts of the well water and a second basketful washed. The tub is then emptied, and a fresh mixture made. The mixture for the second washing also does duty for two basketfuls. The women who

wash the cardamoms are paid 3 annas per diem. An ordinary wage is 1½ to 2 annas. The night watcher receives 4 annas. The nipping is paid for by the piece at the rate of ½ anna per *padi* (10 *padis* = 1 maund = 26 lbs.). It is said that an expert can earn 2½ annas per diem. She must clip 13 lbs. therefore; all other hands employed are paid by the day at 2 annas.

"Besides this bleaching, nowadays cardamoms are starched. Starching was first introduced at Sirsi, where bleachers had recourse to it, as they had to compete with the bleachers at Háveri, who were experts in the art of bleaching, and who had established their fame as such. The starched cardamoms look whiter than the ordinary bleached cardamoms of Háveri, and the bleachers of Háveri have therefore now taken to starching. The starch is prepared by pounding together rice, wheat, and country soap with butter milk. The paste is dissolved in a sufficient quantity of water, and the solution is sprinkled over the cardamoms to be starched as they are being rubbed by the hand." Starching.

In the Kánara gardens a so-called disease has appeared in the cardamom crops within recent years, and is undoubtedly now restricting the cultivation. The affected plants do not present any particular indications of disease. They simply become unthrifty. The leaves in parts become yellow, and then these parts of the leaves wither. The effect is that the plants have no vigour of growth. These unhealthy appearances were first noticed locally, but now the disease (if disease it can be called) is present in many gardens, and extends over a wide area. It may be taken as certain that the cardamom plant, like any other cultivated plant, degenerates when grown for long periods under precisely the same conditions of soil, climate, and without any change in methods of propagation or reproduction. The vigour of any cultivated plant can be renewed from time to time by change of soil, change of seed, by rotation with other crops, and by other regenerating influences. The Kánara cardamom crops have for a long period been grown without any changes in the system of manuring, propagation, and general cultivation, and I have little doubt but the diseased conditions referred to have been induced by these causes. Within recent years borers and grubs have caused considerable damage, and the cultivators assert as a reason that they have been prevented by forest conservation from using for leaf mould the leaves and twigs of certain trees. These trees have astringent properties, and it may be true that leaf mould made from such material would not likely harbour insect life. The grubs cut through the leaves at the base and also cut into the rhizomes. Some of these grubs are identical with the large fat ones Blight.

which are so commonly found in old farmyard manure. Such manure is commonly used for plants in pots, and if these grubs are present they invariably cut through and cut into the roots of potted plants. A gardener, if he sees a plant withering or unthrifty, removes it from the flower pot, and looks for the grub and destroys it if found. I can suggest no other remedy. The fruit of cardamoms is said to be eaten by snakes, rats, and other vermin.

PEPPER—*Piper nigrum*—Linn.

Natural order—*Piperaceæ*.

Gujaráti, *Mari;* Maráthi, *Miri;* Kanarese, *Menasu*.

Habitat and general character of the plant.

The commercial product is the dried fruit of a vinelike plant which is found wild in the forests of Malabár and Trávancore. The plant is cultivated largely in Southern India, Siam, Malaya, Cochin-China, and other tropical parts with moist hot climates. A rainfall of 100 inches or more appears to be necessary. The plant is a large climber. The leaves are glossy, acute, cordate. The flowers are pendulous spikes and the fruit red berries, the size of peas in racemes. The berries are fleshy. The pulp covers a soft stone. The plants in climbing cling by adventitious roots very closely to any support. In the Kánara gardens pepper is trained on the *supári* palm trees.

Cultivation.

The plant is propagated by layering or from cuttings. The former is the preferable plan. When the betel palms have been seven or eight years permanently planted, pepper is planted at the roots of the trees. If a long healthy vine from an established plant can be stretched to reach the root of the betel palm, this vine is layered in the leaf-mould manure which surrounds the roots of the palm. The pepper vine takes root freely in this manure, and, when it has done so, is severed from the parent plant and trained on the palm stem. Two or three vines are layered to one palm. The best months for propagating by layering or otherwise are June or July. The young pepper plant grows rapidly. The main vine should branch freely into subordinate vines, so that a number of vines can be trained straight up the palm. They are fully secured to the stem by bands stripped from the sheaths of fallen leaves of the betel palm. The bands are tied about a foot apart, and in well managed gardens are renewed annually at the top and twice a year at the bottom; but in a young plantation a band must be put on from time to time as the vines grow. The main and subordinate vines grow up the tree to a height of five feet or more per annum. Luxuriant growth and free branching are encouraged by heavy applications of good manure given annually for three years after plantation. Subsequently the pepper participates in the general cultivation given to the betel palms,

and an application of manure is given for both crops every second year. The manure is heaped over the bared roots of the betel trees and pepper plants in a circle round the stems, and, if plentiful, a big basketful is given to each betel palm, less being given if manure is scant. The basket is saucer shaped, about 3 feet in diameter and 15″ to 18″ deep in the centre. The best manure for pepper, betelnut, and all other crops of the garden is made from green leaves and twigs plucked or pruned in the monsoon and used as litter in the byres where buffaloes and other cattle stand, and thence removed to a deep manure pit every day or second day with the dung and urine of the cattle. This manure is sufficiently decayed by the following March, and is applied in that month or in April. The pepper plants in an established plantation rise to a height of 15 to 20 feet. Throughout their whole length they send out horizontal branches which are generally about 18″ long. The foliage in healthy plants is from the ground upwards fairly dense, but in an established plantation some of the older vines die. Then the foliage becomes less dense unless the plants are renewed by new layers. A plantation is in bearing three or four years after it is started, and if the old vines as they get worn out are at once replaced by new layers, the plantation should keep in vigorous growth and bearing for a long period. The flowers appear in July and August, and the berries are ripe in March. The yield depends upon liberality in manuring and careful management, also upon the rainfall. The rainfalls of June and July are important, as these cause the plants to produce many flowers; but if the rains come in heavy downpours subsequently, the inflorescence may be destroyed before it fairly sets. If there is a long break after the first rains, the flowers may wither. With light showers, however, a full crop may be expected.

Yield.

The vines on one palm when in full bearing yield in a good season about 1,000 clusters on an average. The clusters vary in size, but 1,000 should yield about 7 *sers* of dried pepper (a *ser* = 24 *tolas*).

Gathering the fruit.

The plants, the flowers, and the fruit are delicate in the sense that they are damaged by rough handling. Therefore, ladders are used when the vines are bound to the palms and the berries plucked. The ladders are straight single bamboos, with the alternate side branches cut off about a foot from the stem. These provide the steps of the ladder. A wooden hook is rigidly attached at the top end of the ladder, and secures it to the palm above the level of the tallest pepper plants. The ladder is slightly inclined in a certain direction when in proper position, and then can be safely used as it cannot well slip. The bunches are plucked by hand and placed in an oblong cane basket slung horizontally behind the workman by a rope round

his waist. The rounded ends of the basket project a little on either side, so that the basket can be conveniently filled by either hand of the workman. When plucked, all the berries in a bunch may be equally and fully ripe, but ordinarily the bunches are plucked when the berries are mostly green and just changing in colour.

Preparing for market.

The berries may or may not be sorted as they are plucked. If they are sorted, those fully ripe are separated. These are soaked in water for seven or eight days or heaped, so that the pulp ferments, and then rubbed by hand or on a coarse cloth if the quantity is small, or trampled under the feet of coolies if large. The pulp is thus rubbed off the inner "stone." The stone furnishes the white pepper of commerce. The pulp is completely removed by washing in baskets in running water. The pepper is then dried by exposure to the sun for about a week. This has also a bleaching effect, and the pepper becomes pale grey or palo drab in colour. It can be bleached a whiter colour by chemical agency. This white pepper is only prepared to a limited extent in the Kánara forests. The chief product is black pepper. It is got from unsorted berries which are heaped up for four days. The green berries then get softer and change colour, and the pulp of all is more or less squashed. Then the berries are spread out and dried. The skin and part of the pulp adhere as a dry, dark coloured, wrinkled covering to the stones, and the pepper is black in appearance. White pepper is worth Rs. 10 to Rs. 11 per maund. Black pepper is worth Rs. 7 to Rs. 8 per maund.

Manures used in Kánara Spice Gardens.

The owners of spice gardens in Kánara depend chiefly upon leaf mould for manure. They have never used manure of any other description, and have no faith that ordinary cowdung manure, oil cakes, or other concentrated manures would serve their purpose equally well. They consider that the best leaf mould manure is got from the green leaves and small succulent branches of certain trees which during the monsoon are used as litter under the feet of cattle tied during night and the greater portion of the day in sheds. This litter is freely used, five large headloads being brought daily for about twelve cattle. The litter having absorbed, the urine and dung is removed daily or every second day, and put in square pits which are generally about 8 feet deep. These pits are dug in situations where they catch the whole direct rainfall, which is very heavy, and possibly also a good deal of drainage water from higher levels. The subsoil is very reten-

tive, and there is probably not much drainage through the subsoil from the manure pits, but the contents of these pits must be continuously wet during the monsoon. For each acre of garden an owner would like to have four cattle. He owns always a milch buffalo or buffaloes, but keeps no work cattle as all the garden labour is manual. If he does not own sufficient cattle, he hires them, feeding them gratis for the value of the manure produced. The hiring of cattle is a common practice. They are chiefly fed on dry grass which is of very inferior description. They probably also eat part of the litter as some of the leaves used are liked by cattle. Milch buffaloes get safflower cake or cotton seed, both imported from Hubli (Dhárwár District), and it is rather significant that the gardeners think leaf mould got from buffalo litter is best for manure. Some owners feed cotton seed or cake to all their cattle in the monsoon, and I have no doubt they find it pays to do so, because ordinarily the cattle are, during this season, miserably thin and unhealthy. Many cattle are brought in from Dhárwár, but only survive a few seasons in the feverish climate of Kánara.

In the fair season the cattle get a good deal more freedom, still they are kept in the sheds for probably about fifteen hours in the twenty-four, and the sheds are littered freely. The rough grass is supposed to be given as fodder, but is spread all over the floor in the sheds, and the cattle eat only a small proportion of it. Again, at this season dry leaves are collected and also used as bedding. But the gardeners think dry fallen leaves poor stuff, and discount the value of such as manure. The manure put in the pits in the hot weather has a full year to decay, the manure being used always in February and March. That which is made during the monsoon has less time to decay, and the gardeners attach particular value to the green leaves and twigs of certain trees collected during the monsoon, because such decay very quickly. Such leaves are generally large and fleshy, and are much more easily collected than smaller ones. A man can collect and carry to the cattle shed five head loads per day. The leaves and branches of other trees are also held in high esteem for leaf mould, because the manure produced has the reputation of destroying insects and grubs which would be harmful to the plants in the garden. The trees which provide leaves of the latter class have all unquestionably astringent properties, and it is perhaps reasonable to believe that vegetable matter containing astringent resins or volatile oils might destroy insect life or that insects would not be likely to harbour in such material. The gardeners assert that since they have been denied the use of the leaves of certain reserved trees, grubs and borers have become

destructive to their cardamom plants and betel palms, these insects causing damage first at the roots.

It is impossible for me to say what weight of manure is actually applied per acre. But, judged by the eye, I think it is certain that the application is at least equal to a heavy dressing for ordinary garden crops. It probably approximates thirty ordinary cart loads per acre per annum, perhaps more.

The invariable practice is to put the leaf mould immediately over the roots round the stems. The circle would be 3 or 3½ feet in diameter. It is urged that the leaf mould, if unprotected, would be washed away by heavy rainfall, and this is perhaps true, and in consequence a good deal of branchwood cut green in the hot weather, so that the leaves adhere, is used to cover the leaf-mould. The branchwood which is most desirable is such as will slowly decay and has astringent properties, *i.e.*, has the power of keeping destructive insects away. The branches of *jambe* (*Xylia dolabriformis*) and *nelli* (*Phyllanthus emblica*) have the two qualities referred to in a special degree. The branchwood used does not readily decay. It affords considerable protection to the leaf mould. A year after it is applied the leaves have decayed, and the branches are partly rotten, still they would break the force of heavy rain. It might be urged that a covering of soil over the leaf-mould would be sufficient protection, especially as the soil of these gardens is of a decidedly adhesive character. It is possible that this adhesiveness would tend to exclude air and moisture from the leaf mould and prevent it serving its purpose as manure. But I do not believe such would be the case. At Bassein in the Thána District, with a rainfall as heavy as that in Kánara, the manure given is put round the roots of the plantains, betel vines, and other crops, much in the same way as in Kánara, and protected by a covering of soil. The soil is, however, a light alluvial sand, and the manure is not washed away. The manure used at Thána is cowdung manure and castor cake, chiefly the latter, and it is given in several applications every year. The question is, can a manure of this class be economically substituted for a portion at least of the very heavy and very expensive dressings of leaf mould now applied? I consider that the leaf mould manure is expensive, even although its production requires only labour in collection and the keeping and feeding of cattle.

Castor cake and safflower cakes are produced on a large scale in the Dhárwár District, and are obtainable at very moderate rates by the Kánara gardeners. It might, therefore, be advisable to experiment with these manures and prove their effect.

Forest Lands assigned to Gardens.

The more common trees in *beta* lands and in protected forest, which are specially useful to the cultivators for manure purposes are referred to in short detail below :—

Kaval or Kavla (*K.*) (*Careya arborea*).—Leaves big, fleshy, soon rot as green manure, and considered specially good for leaf mould. Trees abundant in *beta* lands.

Honne (*K.*) (*Pterocarpus marsupium*).—Leaves are rather small, and are not considered particularly good for leaf-mould. The leaves are excellent fodder, and this probably is the principal reason why leaves are taken. Tree yields a gum used in medicine, and which is largely exported.

Jambe (*K.*) (*Xylia dolabriformis*).—Used more as a covering for the leaf mould manure as light branchwood than for leaf mould. Does not decay quickly. Yields a red resin, and probably on this account the wood resists ants and other vermin. Heartwood very hard. Timber used for carts and other agricultural implements and for furniture, &c.

Hirda (*M.*), *Alate* (*K.*) (*Terminalia chebula*).—The best leaves of all for green leaf mould. Supposed to kill insects and grubs. Leaves small and do not rot very quickly. Tree yields a gum used in commerce. Dried fruit yields a dyeing and tanning material. Oil in kernel of fruit. Fruit used medicinally in many ways. Leaves eaten as fodder by cattle. Wood hard, close grained, durable, seasons well, used for furniture, implements, &c.

Kanagal (*K.*) (*Dillenia pentagyna*).—Leaves are good for leaf mould. They are very large and fleshy, and decay very quickly. Flowers, buds, and fruit eaten. Berries eaten greedily by deer and other animals. Wood not much used except for firewood or charcoal.

Honal (*K.*) (*Terminalia paniculata*).—Considered nearly as good as *mátti* for leaf mould. Leaves not large and do not decay particularly quickly. Bark and fruit said to be used for dyeing and tanning. Wood useful for many purposes.

Matti (*K.*) (*Terminalia tomentosa*).—Leaves and branches considered excellent for leaf mould. Leaves large and easily collected. The bark of *mátti* when burnt leaves an ash which consists mostly of calcium carbonate, and this lime is used with betel leaf (*pán*). Yields a gum reddish brown with bitter disagreeable taste. Bark used for dyeing and tanning. Leaves used as cattle fodder. Wood useful for many purposes.

Nerlu (*K.*) *or Jámbhul* (*M.*) (*Eugenia jambolana*).—Used to a considerable extent for leaf mould or for branchwood ; used as a covering over leaf manure. Yields a gum. Bark used for dyeing and tanning. Wood not much used for anything except firewood.

Bite (*K.*) (*Dalbergia latifolia*).—Blackwood. Reserved as a valuable timber tree.

Nelli (*K.*) (*Phyllanthus emblica*).—Fruit, bark, leaves, all used for tanning. Used medicinally; contains gum. Branches used as protective covering for young cardamom seedlings. Fruit and leaves good fodder. Wood used for building and agricultural implements.

Surhonne (*K.*) (*Callophyllum tomentosum*).—Sirpoon tree. Evergreen tree. Yields a black gum. Seeds yield oil, tree tall, straight, and used for masts and buildings. Found in *káns*, not in *beta* lands or protected forest.

Kari muttala (*K.*) (*Ougeinia dalbergioides*).—Yields an astringent red gum. Leaves used for fodder. Bark astringent and used to poison fish. Tree small, otherwise would yield timber suitable for many purposes.

It will be noticed that the unreserved trees which are reported to give the most useful leaves and branches for garden requirements have no great value as timber trees. The pollarding practised unquestionably shortens the life of trees. It will also diminish their fuel value when dead, because they have spent their substance in producing by unnatural treatment leaves and small branches instead of natural growth. The result justifies the means, because small branches and leaves are specially required by the gardeners. A large, well-balanced tree with straight stem, shapely limbs and dense foliage carries, no doubt, a wealth of leaf growth that a Kánara gardener would like to collect. But how is he to do so? He could manage it by dismembering the trees and getting the big branches on the ground. This is practically what he does when he first pollards and lops. Afterwards the foliage (it is cut every second year) is within easy reach and for a number of years a large amount of foliage and light branchwood is produced. In course of time the tree dies prematurely by exhaustion or ill-health induced by bad usage; but if young trees of suitable variety are so protected that they replace old decayed trees, and if pollarding is prohibited until young trees attain certain dimensions, as proposed by the Committee in the draft rules, then I think the interests of Government will be fully safeguarded, and the requirements of the gardens fully maintained. I saw numerous instances of well managed *beta* lands. I saw also instances of ruthless destruction with the surface burnt to encourage grass, and no forest undergrowth to speak of, but side by side with these badly managed *beta* lands there was even greater destruction in protected forest, for which the people at large and not the garden owners alone, were responsible.

The collection of green leaves and branches in forests discussed.

It has been suggested that the full requirements of the garden occupants could be met if they gathered dead leaves and grass in enclosed forest to supplement the supplies of green leaves and twigs got from assigned *beta*. It is also urged that the dead leaves and grass would not be less valuable for manure than green leaves and twigs. I cannot support these views. Leaves as they become perfected dry up and become fibrous, and a good deal of the plant-food, both mineral and organic, which they contained when green and growing, passes from them, and is utilized in increasing the size of the stem or branches and in perfecting the fruit. There can be no question at all, therefore, as regards the superiority for manurial purposes of the green leaves of a particular tree over the dead leaves from the same tree. The dead leaves fall, moreover, at a particular season and have to be collected at that particular season; otherwise they soon become incorporated with the soil and disappear. If put in deep pits they would in the course of a year decompose into what is known as a leaf mould by gardeners. This material would, in my opinion, have inferior manurial value to the manure now used. I am convinced that such would be the case from the results of analyses by the Agricultural Chemist to the Government of India of the various descriptions of green leaves and small twigs ordinarily used. I sent him the leaves and twigs of eight different varieties of trees, the varieties being such as are considered best for leaf manure. The analyses are appended below :—

Dead leaves not so good as green leaves.

Dr. Leather's analyses of various leaves.

	Kaval Leaves (*Careya arborea*).	*Ippi* Leaves (*Bassia latifolia*).	*Honne* Leaves (*Pterocarpus marsupium*).	*Jambe* Leaves (*Xylia dolabriformis*).	*Hirda* Leaves (*Terminalia chebula*).	*Kanagal* Leaves (*Dillenia pentagyna*).	*Honal* Leaves (*Terminalia paniculata*).	*Watti* Leaves (*Terminalia tomentosa*).
Moisture ...	80·66	78·95	78·77	73·31	77·77	87·06	75·06	81·86
Dry matter	19·34	21·05	21·23	26·69	22·23	12·9	24·94	18·14
Organic matter ...	18·00	19·60	19·58	25·24	20·90	11·68	23·42	16·74
Mineral matter ...	1·34	1·45	1·65	1·45	1·33	1·26	1·52	1·40
Silica ...	·08	·10	·12	·11	·04	·08	·12	·07
Potash(K_2O)	·43	·43	·53	·44	·30	·41	·40	·44
Phosphoric acid (P_2O_5)	·086	·097	·095	·08	.078	·070	·100	·080
Nitrogen ...	·31	·43	·54	·62	·40	·24	·42	·34

The leaves and twigs contained from 73 per cent. to 87 per cent. of water. But even in this succulent condition the percentage of nitrogen and potash (the two most important elements of plant food) were

The manurial value of the leaves compared with farm yard manue.

equal to about half the quantities usually found in well preserved farm yard manure. The air dried material of these leaves and twigs would be considerably richer in nitrogen and potash than air dried well preserved cattle manure. The leaves and twigs are all deficient in phosphoric acid. The contention of the gardeners that certain leaves are better manurially than others is not supported by the analyses. *Hirda* leaves are considered locally very superior for leaf manure, also those of *matti* and *honne*. But the analyses show that other varieties are superior to these for manure purposes. On the other hand, it is fair to state that the leaves of *hirda*, *matti* and *honne* are considered specially valuable, because the manure produced from them destroys insects and grubs which would be harmful to the plants in the garden. These leaves and, in fact, nearly all the leaves used by the gardeners have astringent properties, and it is, I think, certain that vegetable matter containing astringent resins or volatile oils would be obnoxious to insects, and therefore insects or grubs which might be harmful to the plants of the garden would not harbour in such material. Dry leaves, unless collected soon after they have fallen, undoubtedly harbour insect life, and this is one serious objection to their use as manure. I was hopeful that the Agricultural Chemist would be able to state definitely how far the various leaves and twigs submitted for analyses differed in astringent properties. He was, however, unable to investigate this point. I took no samples of dead leaves, because at the time of my visit to Kánara—April—it was impossible to collect samples which could be identified as belonging to any of the particular trees from which green leaves are usually taken. In fact, dead leaves had mostly disappeared by that time. I believe they mostly fall in December-January, and could not, except in trifling quantity, be collected during the monsoon when green leaves and twigs are ordinarily collected as manure. Dr. Leather's analyses clearly indicate that manure of good quality can be made from the green leaves and twigs ordinarily used. The system of trampling the leaves under the feet of cattle, so that the urine and solid excreta are absorbed, would improve the quality of the manure particularly if the cattle are fed partly on cake as is sometimes the case. The storage of manure in deep pits formed in soil and subsoil, which is very retentive, can hardly be improved upon, excepting that the extremely heavy rainfall of the district must keep the unprotected pits excessively wet during the monsoon, and probably valuable manurial ingredients are washed out of the manure at this season.

Leaf manure specially valuable for certain reasons.

I submitted to the Agricultural Chemist to the Government of India four samples of manures. Each sample is sufficiently described in the tabulated statement below :—

Dr. Leather's analyses of leaf-manure.

	Monsoon green leaf-manure. Sample taken from roots of trees to which it was applied in February 1898.	Green leaf-manure as applied to Betel-palms, February 1899. Sample taken in April 1899.	Dry Leaf-manure made from dead leaves used as litter under cattle fed on grass, &c.	Manure made from green leaves collected in the rains and used as litter under cattle.
Moisture	55·07	58·05	56·90	59·72
Dry matter	44·93	41·95	43·10	40·28
Organic matter	23·44	28·74	25·42	26·48
Mineral matter	21·48	13·21	17·68	13·80
Sand	14·69	7·80	11·43	7·47
Potash (K_2O)	·16	·41	·43	·17
Phosphoric acid (P_2O_5)	·14	·18	·12	·17
Nitrogen	·51	·51	·55	·75

The comparative manurial values of the different samples compared.

It is difficult to understand the deficiency of potash in the fourth sample. The nitrogen and phosphoric acid are probably about average for this kind of manure. Samples Nos. 1 and 2 were originally of similar class to sample No. 4. They were, I imagine, superior in quality originally to No. 4. The Kánara system is to apply manure every second year. No. 1 sample (taken in handfuls from many trees) is by no means exhausted fourteen months after application, and it may be inferred from this that the gardener's methods of application and of protecting the manure from surface wash and heavy rainfall by a covering of branchwood and leaves are successful in practice. From personal observation I can say that the branchwood, a full year after being first put on, is sufficient to break the force of heavy downpours of rain, and when first put on or afterwards allows the rainfall to percolate through the manure to feed the plants. It is suggested in the papers by one officer that the gardeners should use the leaf sheaths of the *supári* palm leaves as a protection for the manure instead of the branchwood now used. The leaf sheaths are all required for another purpose in the garden economy, and in any case the manure does not (as Mr. Davidson points out) need a water proof. It needs protection and needs also to soak up the rainfall, as it falls, in a fair and reasonable way. No. 2 sample was taken in the same way as No. 1 in handfuls from above the roots of many trees. The samples were taken two months after application. No. 2 contains less sand than No. 1 for obvious reasons, and probably its original manurial elements had been since application utilized to considerable extent, as the trees and plants were in active growth. The garden soil and the manure were quite

moist, and there had been abnormal, rather heavy, rainfall some little time before the samples were taken. These are conditions which would help the plants to utilize the manurial ingredients quickly. The sample No. 3 from dry leaves used as litter under cattle is quite as good as might be expected. It has about half the manurial value of good cattle dung manure. The owner considered it was poor stuff. The high percentage of sand is noticeable.

The present system of manuring successful in practice.

There is no doubt that the present system of manuring in the Kánara gardens is successful in practice, provided the gardeners are allowed to use in sufficient quantity the kinds of forest produce which they prefer. The system of manuring is expensive, even though the materials are got free, and the destruction caused to forest growth is enormous. Under the circumstances, it would, I think, be most advisable to test by experiment whether available concentrated manures, such as castor cake or safflower cake, could take the place of a portion of the manure now used. These cakes can be imported from Dhárwár at reasonable rates into the district. Castor cake is less valuable manurially than safflower cake, and is dearer. In the gardens of Bassein, with heavy rainfall in light soil, castor cake is successfully used. It is obnoxious to insect life, and if used in the Kánara gardens there would probably be less damage done by grubs and borers which certainly do considerable damage to the garden plants and trees now.

Dr. Leather's analyses of Kánara garden soils.

I append hereto analyses by Dr. Leather of samples of four descriptions of soils which are sufficiently described in the appended tabular statement :—

	Rajawalee earth *e.g.*, the earth excavated from embankments and carried in head-loads to renew the garden soil of old-established garden when renewal is required.	Earth from rice-beds near a thriving spice garden and similarly situated to the garden and presumably capable of being converted into garden.	Soil from old-established gardens.	Soil from new extension of an old garden.
Lime (CAO) total	·11	·09	·15	·19
Magnesia (M g O) total	·30	·30	·29	·38
Alkalis total	1·07	·31	...	...
Potash total	·154	·071	·110	·27
Potash (K_2O) available	·003	·008	·004	·005
Phosphoric Acid (P_2O_5) total ...	·086	·04	·073	·074
Do. available ...	·001	·0017	·0005	·0015
Nitrogen total	·014	·20	·09	·18
Nitric Acid (as Nitrates)	·0009	*Nil.*	*Nil.*	·003

Dr. Leather says the samples are all deficient in lime, phosphoric acid, and more or less so in available potash. I should, as a matter of

fact, class them as agriculturally poor; but in my extended notes regarding the garden cultivation I remarked that it does not matter much whether the garden soil is naturally fertile or not, because the yield of the crops is mostly affected by the quality and quantity of manure given. As regards the soil, it must be of such consistence that it withstands the denuding effect of flood water, and be so retentive of moisture that little or no irrigation is required in the fair season. All the samples submitted to Dr. Leather possessed these desirable qualities. It has been already shown that the leaves and twigs used by the cultivators are rich in potash and also in nitrogen, in which the soils are decidedly deficient. It has also been shown that the trampling of the leaves under cattle and the absorption of the excreta particularly, if the cattle are partially fed on cake, improves the resultant manure in phosphates. Dr. Leather has not separately estimated the amount of lime in the manures, but he shows that the soils are deficient in this important ingredient. I have already stated that the *matti* tree when burnt leaves an ash rich in lime, or, according to local opinion, it yields *chunam*. The cultivators are specially anxious to be allowed to take the leaves and twigs of this tree. If the manure applied to the trees in the Kánara gardens was mixed, as in common agricultural practice, freely with the soil, then the soil in old established gardens would probably be richer in manurial ingredients than new soil. I conclude from a study of Dr. Leather's analysis that the system of manuring, as practised in the gardens of Kánara, is as right in theory and practice as it well can be, provided the manure as it accumulates in the pits is subjected in the least possible degree to the wasteful wash of the heavy Kánara rainfall.

INDIGO—*Indigofera tinctoria*—Linn.

Natural order—*Leguminosæ.*

Sub-order—*Papilionaceæ.*

Tribe—*Galegeæ.*

Maráthi, *Nili*; Gujaráti, *Gali*; Kanarese *Nili.*

Habitat.

Various forms of *indigofera* are found wild in various parts of India. Dr. Watt says there are about 300 species of *indigofera* in the tropical parts of the globe and chiefly in Africa. India has about forty species. He doubts whether *I. tinctoria* has ever been found wild in India. The supposed wild forms of *I. tinctoria* found in India are not far remote from places where it is cultivated.

General character of the plant.

I extract from Duthie and Fuller's botanical description as under:—A small shrub, 4 to 6 feet high, with silvery pupescent, tough, angular

branches; leaves alternate 3 to 4 inches long with minute subulate; stipules unequally pinnate; petiole ½ to 1 inch long; leaflets opposite in pairs of four to six and a terminal one, shortly stalked, obovate oblong or oval, entire, smooth, bluish green above, and with adpressed white hairs on lower surface. Racemes stalked, axillary, erect, spikelike. Flowers small, short stalked, rather crowded. Pods 1 to 1½ inches long, straight or sub-falcate, cylindrical, somewhat contracted between seeds, 8 to 12 seeded, seeds quadrangular, brown.

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Distribution in Bombay.

Indigo is now very sparingly cultivated in the Bombay Presidency. In former times it was extensively grown in Gujarát, and the ruins of steeping vats can be seen in many villages. Cheaper analine dyes have been largely substituted in India for those of vegetable origin, hence the decline of the indigo industry in Bombay. The indigo area in Bombay varies from 2,000 to 3,000 acres annually. The chief centres of cultivation are Khándesh, Broach, Kaira, Ahmedabad, Ahmednagar, Sholápur and Dhárwár.

Soil and season, &c.

In Gujarát the best crops are grown on *goráḍu* soil (deep, sandy, loam alluvium). In the Deccan medium black soils of fair depth are most suitable. The crop is grown in the *kháríf* (rainy) season in Bombay.

Cultivation in Gujarat.

Thorough tillage and a liberal application of manure are necessary. Well rotted manure in a dressing of twenty cart loads per acre should be given in May. The plough and harrow should be used after the first fall of rain to prepare a clean, smooth seed bed.

The crop is either sown alone or with subordinate rows of cotton. One row of cotton alternates with two rows of indigo. When sown alone, the seed rate is 12 to 15 lbs. seed per acre. The seed should be drilled if possible in June in rows 18″ or less apart, and the drill should be worked near the surface, so that the seed is not buried too deeply. The crop should, after the seedlings are well up, be intercultured two or three times with the bullock hoe, and be once hand weeded with the weeding hook (*khurpa*). The first cut is ready in September-October. With favourable late rain, a second cut may afterwards be obtained without irrigation.

Harvesting and extracting the dye.

The crop is reaped close to the ground with a sickle immediately before flowering. The plants are reaped in the morning, and carried to the vats in the afternoon. The dye is obtained from the leaves. These are sometimes sun dried, stored, and the dye extracted at any convenient season afterwards. Loss of dye matter is caused by exposure to rain.

Fermentation.

The first process of dye extraction is to pack the newly cut crop in the fermenting vat which is 4 to 5 feet deep. Water is then

let in until it fills the vat. The mass is weighted down with logs. Next morning the muddy looking extract is drained to a vat at a lower level, and the spent stalks removed. The fermentation of the stalks and extraction of dye material in the first vat should take thirteen or fourteen hours and less time in warm weather. The quality of the dye is lowered if the time allowed for extraction and fermentation is unnecessarily prolonged. The proper time to empty the fermenting vat is when the mass begins to shrink. At first it heaves and increases in volume, then gradually shrinks.

Oxidation.

The muddy extract, after it is run into the oxidizing vat, is trampled and beaten with paddles or sticks to expose it as much as possible to the action of the atmosphere, the effect of which is to change its dull green colour to a deep blue. Subsequently, after settling and rest for twelve hours, the supernatant water is removed with some degree of care in earthen vessels, but the sediment being thus agitated, considerable loss occurs. It is the custom in some places after the spent stems have been removed to leave the extract in the fermenting vat until oxidation and settling is completed as described.

Preparing the dye for market.

The indigo made in Gujarát is impure and only suited for sale to country dyers, principally because it is not cooked as is the practice in the factory system. It is merely drained free of water, and hung up on trees in bags to dry, the usual practice being to place the thickened mass of precipitate on a sheet suspended by its four corners, so that the edges are slightly raised from the ground. After exposure and draining for a day, the corners of the sheet are tied up, and the mass suspended clear of the ground to complete the draining. When nearly dry, it is spread on a clean floor, and when of proper consistence cut into cubes or shaped into small conical *golis*, and is now ready for market.

Outturn, value.

The first crop yields 25 to 30 lbs. of indigo, worth Re. 1 to Re. 1-4 per lb. The cost of manufacturing this quantity comes to about Rs. 8. The second crop is reaped in November-December. The yield is less than the first crop and the dye inferior. The second crop is generally dried, and the leaves stored. A dealer generally buys the crops produced by several cultivators. The dried leaves are worth Rs. 2 to Rs. 2½ per local maund (38½ lbs.). The extraction of the dye is undertaken by Dheds and other low-castes. Kunbis, Kolis and other good agriculturists do not grow the crop, and the cultivation accordingly suffers.

Indigo refuse is a good manure. (1)

(1) The description is principally derived from notes supplied by Mr. P. R. Mehta, M.R.A.C., of the Gujarát Revenue Service.

Cultivation in Northern India.

In the North of India recently constructed canals have offered facilities for irrigating the crop, and, in consequence, the prevailing custom is to broadcast the seed in spring 16 lbs. per acre on a well prepared seed bed. The first cut is ready in August. A good crop yields 8 to 10 tons of green produce per acre, from which 50 to 60 lbs. of marketable dye can be prepared. Cloudy wet weather about the time the crop matures lessens the quantity of dye matter formed in the leaf. Spring sown indigo may be seriously damaged if the monsoon rains are late. It is not usual to take a second cut unless the crop is saved for seed. The more common practice is to grow wheat or barley as a second crop in the same year, the land being again prepared for indigo by repeated ploughings, usually three to five as soon as the cereal is harvested. Indigo sown in June is sometimes ratooned in the following year, when, if the land is clean and otherwise liberally managed, a better crop than the first is often obtained.

The factory system.

I take the following very clear description of the factory system from Duthie and Fuller's "Field and Garden Crops" :—

The essential parts of an indigo factory are—(1) Two sets of vats, one on a lower level than the other, the upper set being used for steeping the plant, and the lower for concentrating the dye matter ; (2) a boiler and a furnace for boiling the dye ; (3) an apparatus for straining and pressing. The size of the steeping vat varies, but it is usually large enough to contain from 50 to 100 maunds of plant. The plant is packed into the vat which is then filled with water, the plant being kept submerged by some cross bars which are fitted across the vat above it. The time during which this steeping continues varies according to the weather from eleven to fifteen hours, being less in muggy damp weather with the wind in the East than when the air is dry with the West wind. It is of great importance, however, that the steeping should be stopped at the right moment ; if underdone dye matter is lost ; and if unduly prolonged, the quality of the produce suffers. The steeping vats open by a channel into the vat which corresponds with it in the lower tier. When the steeping is finished, a plug is drawn, and the water drained off into the lower vat, leaving the plant behind it, which can be then thrown aside. The water is of a greenish colour, and is charged with a substance known as indican which fermentation has extracted from the leaves. In order to convert this substance into indigotine—the basis of indigo dye—it is necessary to oxidize it, and the next process known as "beating" has this for its object. Usually it is performed by seven or eight men who stand in the water and agitate the liquid either with their hands or with a rake-shaped paddle. As the oxidation proceeds, dark blue particles of indigotine (known

Fermentation.

Oxidation.

collectively as the *fecula*) appear in the liquid which changes in colour from green to blue. The process is continued for from one and-a-half to three hours, and may be stopped as soon as a little liquid placed in a saucer readily throws down a dark blue precipitate, remaining itself of a clear sherry tint. It is now allowed to stand until the *fecula* has settled, which takes place in about a couple of hours, and is sometimes assisted by pouring some cold water into the vat. The surface liquid is then carefully drained out of the vat by holes which have been made in its walls for the purpose, and the dark blue sediment which remains is conducted along a masonry channel into the boiling vat, where it is kept over a moderate fire for about five hours, and is then repeatedly passed through a cloth strainer which effects the separation of the dye matter from the water.

Cooking.

The dye matter is then allowed to lye on the strainer until partially dry, when it is carried to the press and placed in boxes with moveable sides, in which it is subjected to gradually increasing pressure for twelve hours, at the end of which time it will have taken the form of firm slabs, 3½ inches square, which are then cut into cakes of the same length, and are ready for being stamped and finally dried. The whole process from plant to cake occupies, therefore, about 48 hours, and at a large factory one follows the other in constant repetition for some 45 days in August and September.

Pressing and stamping.

Good indigo cake should contain 50 to 60 per cent. of indigotine. It should be bright, of a dark blue colour with a coppery gloss breaking with an evenly coloured fracture. It should not part with its colour by light friction.

Indication of good quality.